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(71) Applicant: MEDAR, INC. [US/US]; 38700 Grand River Avenue, Farmington Hills, MI 48335 (US).

(72) Inventors: MEYER, Frank; 42 Church Road, Wootton MK43 9HF (GB). DE MAGALHAES, Frederico, P.; 2 Winifred Road, Bedford MK40 4ES (GB). CHAPPEL, Benjamin, J.; 23 Burley's Road, Winslow, Buckinghamshire MK18 3BA (GB). COOPER, Christopher, J.; 80 Regent Street, Stotfold, Hertfordshire SE5 4DZ (GB).

(74) Agents: SYROWIK, David, R. et al.; Brooks & Kushman, 22nd floor, 1000 Town Center, Southfield, MI 48075 (US).

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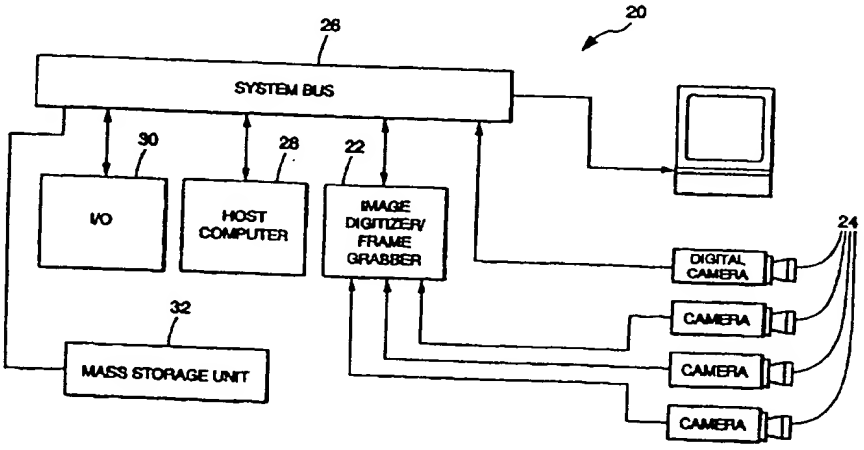

(57) Abstract

A system (28) and a method are provided for quickly developing application software for vision system (20). Hardware parameters are stored in mass storage unit (32) which correspond to possible hardware for use in the machine vision system (20). Commands and set of instructions are received from a user of the computer system to select a first custom control program of desired component, desired hardware operating parameters of desired hardware and a second custom control program of desired machine algorithm. The first control program is linked with the desired hardware operating parameters to the second control program to form the application software and sets the property of one custom control to be equal to one property of another custom control to form the application software in response to the commands and a set of user supplied instructions.

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METHOD AND SYSTEM FOR QUICKLY DEVELOPING APPLICATION SOFTWARE FOR USE IN A MACHINE VISION SYSTEM

Technical Field

This invention relates to methods and systems for developing application software for use in a machine vision system.

Background Art

Application software is the cornerstone of every successful vision system job and normally accounts for the majority of the development effort.

At one extreme there are general purpose vision systems for generic gauging, verification, or flaw detection applications. These systems come with a standard interface configurable with a keyboard and mouse.

Successful applications most often require software changes to cope with individual site requirements. Most general purpose systems are closed, or difficult to modify. Others can only be reconfigured through various programming languages.

There is a need to configure and customize the application in the shortest time, yet provide powerful algorithms. Some systems can be modified using "C". Some require one to learn the supplier's proprietary language. Hiring "C" experts, or taking the time to

learn yet another language, is expensive and time consuming.

Many times generic vision systems are not the answer, so one must build a custom system using a frame grabber or fast vision hardware. Software is typically the most difficult and time-consuming task of any programmable vision system. At best, the board comes with a library of "C" calls or more often a way to program the board at the register level. Not only does one have to program the application and design a Windows interface, one must understand the performance characteristics of the board and its behavior so one can write algorithms that maximize speed. This is a complicated task for someone trying to solve a problem in the shortest period of time.

Typically, this process takes man-years - not man-months. The only vision system developer that can afford this option is one that amortizes engineering over hundreds of systems. With today's frequency of product improvements, even OEMs are having a hard time justifying this approach.

The Intelec Corporation of Williston, Vermont sells a Windows-based software development package that allows users to create machine vision applications and handle a range of machine vision functions. The software provides a dynamic link library interface which allows the end user to add special purpose algorithms for image processing and analysis.

Xiris, Inc. of Burlington, Ontario, Canada makes a software package including image processing

algorithms. The package is configured as a Visual Basic Extension (VBX) to allow the building of automatic inspection applications.

Summary Of The Invention

An object of the present invention is to provide a method and system for quickly developing application software for use in a machine vision system.

Another object of the present invention is to provide a method and system for simply and flexibly developing application software for use in a machine vision system with a graphical user interface such as Windows interface.

Yet another object of the present invention is to provide a method and system for developing application software for use in a machine vision system without the need to develop core vision algorithms and/or complex calibration techniques.

Still another object of the present invention is to provide a cost-effective method and system for developing application software for use in a machine vision system using standard PC hardware and a frame grabber or vision processor while providing a graphical user interface, such as a Windows interface.

In carrying out the above objects and other objects of the present invention, a method is provided for quickly developing application software for use in a machine vision system using a computer system. The method includes the step of storing an application

development program, including a first set of custom control programs representing possible components of a user interface for the machine vision system. The first set of custom control programs define a first set of custom controls. The method also includes the step of storing a second set of custom control programs representing possible machine vision algorithms for the machine vision system. The second set of custom control programs define a second set of custom controls. The method further includes the step of storing hardware operating parameters corresponding to possible hardware for use in the machine vision system. The hardware operating parameters define a third set of custom controls. The method further includes the step of displaying a graphical representation of the possible components, the possible hardware and the possible machine vision algorithms. Then, the method includes the step of receiving commands from a user of the computer system to select a first custom control program corresponding to a desired component of the user interface, desired hardware operating parameters corresponding to desired hardware and a second custom control program corresponding to a desired machine vision algorithm. Finally, the method includes the step of linking the first custom control program with the desired hardware operating parameters to the second custom control program to form the application software in response to the commands.

Further in carrying out the above objects and other objects of the present invention, a system is provided for carrying out the method steps.

The benefits accruing to the method and system of the present invention are numerous. For example, the method and system:

- Simplify and accelerate the process of developing vision applications by using a Visual Programming Environment;
- Utilize image processing algorithms that are robust, accurate, fast, and reliable;
- Reduce software debugging time;
- Develop applications which can easily have a graphical user interface such as a Windows™ user interface;
- Support various processors and various frame grabbers such as Cognex processors;
- Interface to various video sources including analog, digital, and the line scan cameras in addition to other image sources like a scanner;
- Provide programmable tools for various application development environments such as Visual Basic™, Visual C++™, or Borland® Delphi™;
- Use standard technology such as visual basic extension (VBX) technology;
- Include a library of image processing and analysis techniques such as color, distortion correcting calibration, and template matching;
- Provide calibration such as non-linear, 2-D, and 3-D calibration;
- Include components or custom controls for multi-axis motion control;
- Transparently accelerate speed by using on-board vision processing; and
- Operate typically with a single monitor.

The above objects and other objects, features, and advantages of the present invention are readily apparent from the following detailed description of the best mode for carrying out the invention when taken in connection with the accompanying drawings.

Brief Description Of The Drawings

FIGURE 1 is a schematic diagram illustrating a preferred hardware configuration on which the method of the present invention can be implemented;

FIGURE 2 is a schematic diagram illustrating a machine vision system which can be supported by the method and system of the present invention;

FIGURE 3 is a screen display of a Visual Basic programming environment;

FIGURE 4 is a portion of the Visual Basic programming environment after custom controls of the present invention have been added;

FIGURE 5 is a screen display associated with a camera custom control;

FIGURE 6 is a screen display associated with an SE100 custom control;

FIGURE 7 is a screen display associated with a Magic custom control;

FIGURE 8 is a screen display associated with a VP50 custom control;

FIGURES 7-11 are screen displays associated with a editable image custom control;

FIGURES 12-22 are screen displays associated with a search tool custom control;

FIGURES 23-27 are screen displays associated with a blob tool custom control;

FIGURES 28-29 are screen displays associated with a point custom control;

FIGURES 30-31 are screen displays associated with a editable shape custom control;

FIGURE 32 is a screen display associated with a stage custom control; and

FIGURE 33 is a screen display associated with a Type1 stage custom control.

Best Modes For Carrying Out The Invention

Referring now to the drawings figures, there is illustrated in Figure 1 a workstation on which the method and system of the present invention can be implemented. The hardware illustrated in Figure 1 includes a monitor 10 such as a single SVGA display, a keyboard 12, a pointing device such a mouse 14, a magnetic storage device 16, and a chassis 18 including a CPU and random access memory. In a preferred embodiment, the chassis 18 is a Pentium-based IBM compatible PC or other PC having 8 megabytes of RAM and at least 12 megabytes of hard disk space.

The hardware configuration also includes the development environments of either Microsoft Visual Basic, Microsoft Visual C++, or Borland Delphi together with a Microsoft Windows user interface.

Referring now to Figure 2, there is illustrated schematically a machine vision system generally indicated at 20 generally of the type which can be supported by the method and system of the present invention. The machine vision system 20 typically includes an image digitizer/frame grabber 22. The image digitizer/frame grabber 22 samples and digitizes the input images from one or more image sources such as cameras 24 and places each input image into a frame buffer having picture elements. Each of the picture elements may consist of an 8-bit number representing the brightness of that spot in the image.

The system 20 also includes a system bus 38 which receives information from the image digitizer/frame grabber 22 and passes the information on to the IBM compatible host computer.

The system 20 also includes input/output circuits 30 to allow the system 20 to communicate with external peripheral devices such as robots, programmable controllers, etc. having one or more stages.

One or more of the cameras 24 may be an image source such as an analog digital or line scan camera such as RS-170, CCIR, NTSC and PAL.

The system bus 26 may be either a PCI an EISA, ISA or VL system bus or any other standard bus.

The I/O circuits 30 may support a three axis stepper board (i.e. supports multiple axis control) or other motion boards.

The image digitizer/frame grabber 22 may be a conventional frame grabber board such as that manufactured by Matrox, Cognex, Data Translation or other frame grabbers. Alternatively, the image digitizer/frame grabber 22 may comprise a vision processor board such as made by Cognex.

The machine vision system 20 may be programmed at a mass storage unit 32 to include custom controls for image processing, image analysis, third party machine vision products, calibration, and interactive CAD/geometry as described in greater detail hereinbelow. Examples of image processing may include linear and non-linear enhancement, morphology, color and image arithmetic. Also, image analysis may include search, edge, caliper, blob, template, color, 2-D and 3-D measurements.

Third party products may include digital I/O, various camera formats, motion, databases, SPC and others.

Calibration may include non-linear, 2-D, 3-D and color calibration.

Also, interactive CAD/geometry custom control may be provided for both 2-D and 3-D space.

Referring now to Figure 3, there is illustrated therein a Visual Basic programming environment

screen. However, it is to be understood that the programming environment that can be utilized by the method and system of the present invention include other programming environments such as Microsoft Visual C++ or Borland Delphi as well as others.

Referring now to Figure 4, there are illustrated icons of a Visual Basic toolbox which appear after various custom controls, which will be described in greater detail hereinbelow, are added thereto.

Each custom control is generally described as follows:

An editable shape custom control allows a user to define an image processing region by interactively editing a rectangular ellipsoidal or toroidal (donut) shape.

An editable image custom control works like the visual basic picture box control with enhancements that give the user added image viewing and processing options.

A camera custom control allows a user to capture and store live images from a video camera.

A search tool custom control looks for a specific feature in an image that matches a model that a user trained it to recognize; reports the characteristic of the feature found.

A Magic custom control allow the camera control to capture images when the user has a Magic

vision board installed. (This tool is invisible at run time.)

A blob tool custom control finds groups of connected pixels or "blobs" in an image; reports on the characteristics of each blob it found.

An SE 100 custom control allows the camera control to capture images when the user has an SE 100 vision board installed. (This tool is invisible at run time.)

A VP 50 custom control allows the camera control to capture images - and optionally speeds up images searches - when the user has a VP vision board installed. (This tool is invisible at run time.)

A Type I stage custom control allows the stage control to work with a specific manufacturer's stage known as "Type I". (This tool is invisible at run time.)

A Stage custom control allows a user to control a multi-axis stage through a graphical user interface. The developer can include stage control properties and methods in higher level code.

While not shown, a tool board custom control allows a user to navigate through windows and menus in the application by simply clicking buttons on a tool bar.

Also while not shown, a Type II stage custom control allows the stage control to work with a specific

manufacturer's stage known as "Type II". (This tool is also invisible at run time.)

Finally, while also not shown, a Type III stage custom control allows the stage control to work with a specific manufacturer's stage known as "Type III". (This tool is furthermore invisible at run time.)

In general, it is possible to very quickly and easily build machine vision applications or programs using the custom controls illustrated in Figure 4 in the Microsoft Visual Basic programming system. In general, one creates the user interface or a vision application by placing Visual Basic and the custom controls on a form. Next, one sets the properties for both the Visual Basic standard controls and the custom controls. Finally, one writes code to link together the different parts of the application to obtain the application program.

What follows now is a detailed description of the various custom controls of Figure 4 together with example code. Also described for each of the custom controls are various properties for use in forming the application program.

Camera VBX Control

Description

Referring now to Figure 5, the camera custom control allows color or black and white live image views from a video camera and allows static images to be grabbed from the video camera as indicated at area 50 for subsequent processing and analysis. The camera may

be envisaged as a real-world 35mm camera, generally indicated at 52, with a viewfinder 54 to look through in order to compose the image, a button 55 to take a picture, various knobs and switches which control how the image is taken, an image counter 56, and film 57 inside the camera with a number of image frames which can be individually retrieved.

The asynchronous image capture facility allows images to be taken while other work is being performed, thus increasing overall throughput. This is not available on all types of cameras.

File Name

VISION. VBX

Object Type

Camera

Remarks

Before live image views can be displayed and before images can be grabbed, the Camera control must be linked to a camera from a particular vision board. To link the Camera control to the camera from a particular vision board, set the Camera property of the Camera control equal to the Camera property of a vision board control, such as the Matrox Magic control as represented by an icon 58.

To display a live image, click on the viewfinder on the Camera control. To grab an image, click on the shutter release button on the Camera control.

To display a grabbed image, the Editable Image control can be used. Set the RasterImage property of the Editable Image equal to the Image property of the Camera control.

Another way to display live image views and grab images is to use the context sensitive popup menu. To display the popup menu, click the right mouse button over the Camera control.

Camera Control Example Code

Place a camera control, Picture control and a vision board control (e.g. Matrox control) onto a form, and then paste the following code into the declarations section of the form.

```
Sub Form_Load()
     Camera1.Camera=Magic1.Camera
     Camera1.hDisplayWnd=Picture1.hWnd
End Sub
```

Camera Property, Camera Control

Description

Sets or returns the particular type of Camera hardware. This property is not available at design time.

Visual Basic

[*form.*]*Camera*. Camera[=camera&]

Visual C++

pCamera->GenNumProperty("Camera")

pCamera->SetNumProperty("Camera",*camera*)

Remarks

This property must be set to the Camera property of a vision board Control (such as the Matrox

Magic Control), or from another source which provides a compatible property.

Data Type

Long

Camera Property, Magic Control

Description

Returns a value which can be used for the Camera property of the Camera Control. This value is specified by the CameraIndex property. This property is read-only at run time, not available at design time.

Visual Basic

[*form.*]*Magic*.Camera

Visual C++

pMagic->GetNumProperty("Camera")

Remarks

Sets the Camera property of the Camera Control equal to this property at run time.

Data Type

Long

RasterImage Property, Editable Image Control

Description

Sets or returns the image data in the editable image. This property is not available at design time.

Visual Basic

[form.]EditableImage.RasterImage[=*image&*]

Visual C++

```
pEditableImage->GetNumProperty("RasterImage");
pEditableImage->SetNumProperty("RasterImage",
image);
```

Remarks

This property may be set to the Image property of a Camera Control, or from another source which provides a compatible property.

Data Type

Long

Image Property, Camera Control

Description

Returns the image of the currently selected film frame. This property is read-only at run time, not available at design time.

Visual Basic

[form.]Camera.Image[=*image&*]

Visual C++

```
pCamera->GetNumProperty("Image")
```

Remarks

This property may be used to set the Raster-Image property of the Editable Image control, or a compatible image property of any other control.

Data Type

Long

SE100 Control

Description

Referring now to Figure 6, the SE100 Control is a run-time invisible control which provide an implementation of the Camera property for use by the Camera Control represented by camera control icon 52. An editable image or picture box is shown at area 62 in Figure 6.

File Name

VISION.VBX

Object Type

SE100

Remarks

To use the SE100 Control, set the Camera property of the Camera Control equal to the Camera property of the SE100 Control at run time.

SE100 Control Example

Place a Camera Control, a Picture Box Control and a SE100 Control (i.e. icon 60) onto a Form, and then paste the following code into the declarations section of the form:

```
Sub Form_Load()
    Camera1.hDisplayWnd=Picture1.hWnd
    Camera1.Camera=SE1001.Camera
End Sub
```

Camera Property, SE100 Control

Description

Returns a value which can be used for the Camera property of the Camera Control. This property is read-only at run time, not available at design time.

Visual Basic

[*form.*]*SE100*.Camera

Visual C++

pSE100->GetNumProperty("Camera")

Remarks

Gets the Camera property of the Camera Control equal to this property at run time.

Data Type

Long

Magic Control

Description

Referring now to Figure 7, the Matrox Magic Control is a run-time invisible control which provide an implementation of the Camera property for use by the Camera Control represented by the camera control icon 52. An editable image or picture box is shown at area 72 in Figure 7.

File Name

VISION.VBX

Object Type

Magic

Remarks

To use the Magic Control, set the Camera property of the Camera Control equal to the Camera property of the Magic Control at run time.

Magic Control Example

Place a Camera Control, a Picture Box Control and a Magic Control (i.e. icon 70) onto a Form, and then paste the following code into the declarations section of the form:

```
Sub Form_Load()
    Camera1.hDisplayWnd=Picture1.hWnd
    Camera1.Camera=Magic1.Camera
End Sub
```

VP50 Control

Description

Referring now to Figure 8, the VP50 Control is a run-time invisible control which provide an implementation of the Camera property for use by the Camera Control, and the Model property for use by the Search Tool Control represented by the camera control icon 52. An editable image or picture box is shown at area 82 in Figure 8.

File Name

VISION.VBX

Object Type

VP50

Remarks

To use the VP50 Control, set the Camera property of the Camera Control equal to the Camera property of the VP50 Control at run time, and set the Model property of the search Tool Control equal to the Model property of the VP50 Control at run time.

VP50 CONTROL EXAMPLE

Place a Camera Control, a Picture Box Control, a Search Tool Control, an EditableImage Control and a VP50 Control (i.e. icon 80) onto a Form, and then past the following code into the declarations section of the form.

```
Sub Form_Load()
    Camera1.hDisplayWnd=Picture1.hWnd
    Camera1.Camera=VP501.Camera
    SearchTool1.Model=VP501.Model
    SearchTool1.hTrainingImage=EditableImage1.hCtl
    SearchTool1.hSearchingImage=
    EditableImage1.hCtl
End Sub
Sub Camera1_Grab()
    EditableImage1.RasterImage=Camera1.Image
End Sub
```

Camera Property, VP50 Control

Description

Returns a value which can be used for the Camera property of the Camera Control. This property is read-only at run time, not available at design time.

Visual Basic

```
(form.)VP50.Camera
```

Visual C++

```
pVP50→GetNumProperty ("Camera")
```

Remarks

Set the Camera property of the Camera Control equal to this property at run time.

Data Type

Long

Model Property, Search Tool Control

Description

Sets or returns the model data in the search tool. This property is not available at design time.

Visual Basic

```
[form.]SearchTool. Model[=model&]
```

Visual C++

```
pSearchTool→GetNumProperty("Model")
pSearch Tool→SetNum Property("Model",model)
```

Remarks

By default, the model data is stored in the host memory, and the Search Tool methods run on the host CPU. For extra speed, this property may be set to the Model property of a vision board Control (such as the Matrox Control), or from another source which provides a compatible property.

Data Type

Long

Model Property, VP50 Control

Description

Returns a value which can be used for the Model property of the Search Tool Control. This property is read-only at run time, not available at design time.

Visual Basic

```
[form.]VP50.Model
```

Visual C++

```
pVP50->GetNumProperty ("Model")
```

Remarks

Set the Model property of the Search Tool Control equal to this property at run time.

Data Type

Long

Editable Image Control

Description

Referring now to Figures 9-11, the Editable Image control emulates the standard Visual Basic Picture control. In addition, at run time one can zoom and scroll around the image via scroll bars 90, view the coordinates at area 92 and the value of the pixel underneath the mouse cursor, perform image processing operations on the image, and attach a Region Of Interest at 98 to the image. A stretched or distorted image appears at area 99. The image may originate from the usual Picture or Image properties, or from the additional RasterImage property, which can be set to the RasterImage property from a Camera control or another source. The RasterImage property can be passed to Machine Vision controls.

File Name

VISION.VBX

Object Type

EditableImage

Remarks

To scroll around an image, use the scrollbars 90 provided. The scrollbars 90 appear automatically if they are necessary. To zoom into an image, click the left mouse button over the image. To zoom out as illustrated at scaled images 94 and 96, click the middle mouse button. Zooming can also be performed using the context sensitive popup menu 100 in Figure 10. Click over the image with the right mouse button to display the menu 100.

The coordinates and value of the pixel currently underneath the mouse cursor are displayed at the top area 92 of the image. These are only visible if the CoordinatesVisible property is set to true. The cursor keys can be used to move the mouse in single pixel increments.

Image processing operations may be accessed at run time from the popup menu 100. To restrict the image processing to a region of interest 98, place an EditableShape control on the image control and set the hRegionOfInterestShape property to the hCtl property of the editable shape. The selected region is indicated at 102 in Figure 10. The result of performing dilation on a selected image region is indicated at 130 in Figure 11.

To link the Editable Image control to an image grabbed with a Camera control, set the RasterImage property of the Editable Image control equal to the Image property of the Camera control.

Editable Image Control Example

Place an EditableImage control onto a form, load an image using the Picture property, place an EditableShape on the editable image, and then paste the following code into the declarations section of the form:-

```
Sub Form_Load()
EditableImage1.hRegionOfInterestShape = EditableShape1.hCtl
End Sub
```

CoordinatesVisible Property, Editable Image Control

Description

Sets or returns whether the cursor coordinates are visible.

Visual Basic

[form.]EditableImage.CoordinatesVisible[= {True|False}]

Visual C++

pEditableImage→GetNumProperty ("Coordinates-Visible")

pEditableImage→SetNumProperty ("Coordinates-Visible", {True|False})

Remarks

The cursor coordinates are displayed in physical world units, as defined by the Calibration control referenced in the hCalibration property.

Date Type

Integer(Boolean)

hRegionOfInterestShape Property, Editable Image Control

Description

Sets or returns the region of interest of the editable image. This property is not available at design time.

Visual Basic

[form.]EditableImage.hRegionOfInterestShape [=shape&]

Visual C++

```
pEditableImage->GetNumProperty("hRegionOf-
InterestShape")
pEditableImage->SetNumProperty("hRegionOf-
InterestShape", shape)
```

Remarks

This property may be set to the hCtl property of an Editable Shape Control. Once set, all operations on the image will be restricted to the area enclosed by the shape. One can clear the region of interest by setting this property to Null.

Date Type

Long

hCtl Property, Point, Editable Shape, Editable Image, Tool Controls

Description

Returns the control handle.

Visual Basic

```
[form.]Control.hCtl
```

Visual C++

```
pControl->GetNumProperty ("hCtl")
```

Remarks

This property is used to link one control to another. For example, setting the hRegionOfInterest-Shape property of an Editable Image control to the hCtl property of an Editable Shape control defines the region of interest for the editable image to be a particular shape.

Data Type

Long

Search Tool Control

Description

Referring now to Figures 12-22, the Search Tool control is a vision tool which can be trained to locate a specific feature, or model (i.e. 122), within an editable image 121. The trained image appears at area 120. If the model 122 is located within the image a result is produced, which details the location, quality, angle, contrast etc. of the located model. A search region is defined by area 124.

Various properties and methods allow the training and search process to be controlled. These properties and methods can be accessed at design time and also at run time through a context sensitive popup menu 130 of Figure 13. This menu 130 can be accessed by clicking with the right mouse button on the Search Tool control. Figure 14 illustrates the interactive edit of the shape/location of the image region to be trained (i.e. the model) at area 140. Figure 15 illustrates the popup menu 150 which lets the user train the select image as a model. Figure 17 illustrates at area 170 the interactive edit of the shape/location of the search region.

File Name

VISION.VBX

Object Type

Search Tool

Remarks

The Search Tool has both a graphical user interface and a code interface. To use the Search Tool, do the following:

1) The control must first be linked to a Model, Images, Editable Shapes and a Point by setting the hTrainingImage, hSearchingImage and hResultPoint properties. The training and searching images should have their hRegionOfInterestShape property set.

2) Start the training process by either selecting Train from the popup menu or by making the training image region of interest shape visible. Position the editable shape over the desired model in the training image.

3) Train the model, by either selecting Train for a second time from the popup menu (i.e. Figure 13) or by calling the Train. The trained image or model appears in a search tool box 160 in Figure 16.

4) With the searching image region of interest shape visible, position the editable shape to define the searching region.

5) As illustrated in Figure 18, search for the model by either selecting Try from the popup menu 180, or by calling the Search method.

6) As illustrated in Figure 19, area 190 indicates when and where the image model was found in the search region. The

results of the search may now be accessed through the relevant properties.

Figure 20 illustrates a screen which is called from the search tool popup menu and is used to set training parameters. Figure 21 illustrates a screen which is also called from the search tool popup menu and is used to set search parameters. Finally, Figure 22 illustrates a screen also called from the search popup menu and is used to view the search results.

Search Tool Example

Place two EditableImage controls onto a Form. Place one Editable Shape control on each EditableImage control and set the Visible property of these Editable Shapes to False. Place a Search Tool onto the form, then paste the following code into the declarations section of the form:

```
Sub Form_Load()
SearchTool1.hTrainingImage=EditableImage1
SearchTool1.hSearchingImage=EditableImage2

EditableImage1.hRegionOfInterestShape
=EditableShape1
EditableImage2.hRegionOfInterestShape
=EditableShape2
End Sub
```

Error Messages, Search Tool Control

The following table lists the trappable errors for the Search Tool control.

Error number Message explanation

32001 HTRAININGIMAGE_NOT_DEFINED
A training image must be defined.
This error is caused by attempting to train a feature model when the hTrainingImage property is not set.

32002 HSEARCHINGIMAGE_NOT_DEFINED
A searching image must be defined.
This error is caused by attempting to search for a feature model when the hSearchingImage property is not set.

32003 HRESULTPOINT_NOT_DEFINED
A result point must be defined.
This error is caused by attempting to search for a feature model when the hResultPoint property is not set.

hResultPoint Property, Search Tool Control

Description

Sets or returns the Point in which to return the location of the feature model as found by the last Search method. This property is not available at design time.

Visual Basic

[*form.*]*SearchTool* .hResultPoint[= *hCtl%*]

Visual C++

```
pSearchTool->GetNumProperty ("hResultPoint")
pSearchTool->SetNumProperty ("hResultPoint",
hCtl);
```

Remarks

This property should be set before searching for a feature model. It should be set to the hCtl property of a Point control which is on the hSearchingImage. When the Search method is called, the Point will

be set to the location at which the feature model was found. If MaximumNumberOfResults is more than one, set the hResultPoint property to an array of Points. The array should have at least MaximumNumberOfResults entries. The location result may also be accessed through the ResultX and ResultY properties.

Data Type

Long

hTrainingImage, hSearchingImage Property, Search Tool Control

Description

Sets or returns the Editable Images to be used by Train and Search.

Visual Basic

```
[form.]SearchTool.hTrainingImage[= hCtl&]
[form.]SearchTool.hSearchingImage[=hCtl&]
```

Visual C++

```
pSearchTool->GetNumProperty ("hTrainingImage");
pSearchTool->SetNumProperty ("hTrainingImage", hctl);
pSearchTool->GetNumProperty("hSearchingImage");
pSearchTool->SetNumProperty("hSearchingImage", hctl);
```

Remarks

These properties must be set before training a feature model or searching for a feature model. They should be set to the hCtl property of an Editable Image control. It is possible to making the training and searching image the same by setting hTrainingImage and

hSearchingImage to the same hCtl of the same Editable Image. Both the training image and the searching images should normally have a region of interest defined by setting the hRegionOfInterestShape property of Editable Image.

Data Type

Long.

Blobs Tool Control

Description

Referring now to Figures 23-27, the Blobs Tool control (at area 231) is a vision tool which computes various geometric, topological and other properties of objects within an editable image 230. The image is segmented into groups of connected pixels (blobs), and then properties such as area, perimeter, and orientation are computed and can be individually retrieved.

Various properties and methods allow the Blobs finding process to be controlled. These properties and methods can be accessed at design time and also at run time through a context sensitive popup menu 232. This menu can be accessed by clicking with the right mouse button on the Blobs Tool control.

File Name

VISION.VBX

Object Type

Blobs Tool

Remarks

The Blobs Tool has both a graphical user interface and a code interface. To use the Blobs Tool, do the following:

1) The control must first be linked to an Image by setting the hImage property. The image should have its hRegionOfInterestShape property set.
2) Position an editable shape (i.e. 235 in Figure 23) to define the region in which blobs are to be found.
3) Find the blobs (as illustrated in Figure 24 at area 240) by either selecting Try from the popup menu, or by calling the Find method.
4) The Blobs results may now be accessed through the relevant properties.

The screen of Figure 25 is called from the menu 232 and is used to set/view the blob analysis parameters. The screen of Figures 26 and 27 are also called from the menu 232 and is used to set/view blob analysis thresholds. The screen of Figure 27 is also called from the menu 232 and is used to set/view the blob analysis parameters.

Blobs Tool Example

Place an Editable Image control onto a form, place an Editable Shape control on the image, place a Blobs Tool onto the form, and then past the following code into the declarations section of your form:

```
Sub Form_Load()
    BlobsTool1.hImage=EditableImage1
```

```
        EditableImage1.hRegionOfInterestShape
        =EditableShape1
    End Sub
```

Error Messages, Blobs Tool Control

The following table lists the trappable errors for the Blobs Tool control.

Error number	Message explanation
32001	HIMAGE_NOT_DEFINED This error is caused by attempting to find blobs when the hImage property is not set.

Point Control

Description

Referring now to Figures 28 and 29, point, as represented by icon 280, is a Visual Basic custom control that provides a Geometric Point entity which can be interactively edited by its user at both design and run-time as illustrated by point editing options 282. Coordinates of the point in pixels is illustrated at area 283.

File Name

VISION.VBX

Object Type

Point

Remarks

Points can be selected and moved interactively at run-time using the mouse as illustrated in Figure 29. The coordinates are updated as the point icon is moved.

Point position can be finely tuned (i.e. tunable option) by:

Using a special toolbar that moves a Point by one pixel in the required direction.

Pressing Cursor Keys on the keyboard when the Point is selected.

Pressing the Left Mouse Button when the mouse is in a Nudge Zone. These are areas around the point which cause the cursor to change shape. Pressing the Left mouse button when the cursor is one of these Nudge Cursors will cause the Point to move one Pixel in the relevant direction.

The application programmer can prevent the end user from moving, selecting, or fine tuning Points by setting the relevant property to False.

Point Control Example Code

The following example is a simple application that demonstrates the Point custom control. It consists of a minimal User Interface that sets the properties of a point at runtime. It also demonstrates property retrieval and custom events by writing some text on the screen that indicates the position of the point after it has been moved.

To use the example, take the following steps:

1. Make sure that the file VISION.VBX has been added to the project.

2. Create the User Interface:

Place CheckBox controls on the default Visual Basic Form. The names of the four CheckBox controls should remain at default (i.e. Check1, Check2, Check3 and Check4).

Optional: set the CheckBox controls' Caption properties as follows:

CheckBox	Caption
Check1	Enabled
Check2	Movable
Check3	Tunable
Check4	Visible

Place a Label control on the form. The control's Name should be Label1.

Place a Point custom control on the form. The control's Name should be Point 1.

3. Add the code.

Paste the following code in the Declarations section of the form:

```
Sub Check1_Click()
     If Check1.Value = 0 Then
          Point1.Enabled = False
     Else
          Point1.Enabled = True
     End If
End Sub
Sub Check2_Click ()
     If Check2_Click()
          Point1.Movable = False
     Else
          Point1.Movable = True
     End If
End Sub
Sub Check3_Click()
     If Check3.Value = 0 Then
          Point1.Tunable = False
     Else
          Point1.Tunable = True
     End If
```

```
End Sub
Sub Check4_Click ()
     If Check4.Value = 0 Then
          Point1.Visible = False
     Else
          Point1.Visible = True
     End If
End Sub
Sub Point1_Move ()
     label1.Caption = "x=" & Point1.X & " y="
     & Point1.Y
End Sub
```

Add the following code in the default form's Load event:

```
Initialize the Check boxes at start of program
If Point1.Enabled=True Then Check1.Value=1
If Point1.Movable=True Then Check2.Value=1
If Point1.Tunable=True Then Check3.Value=1
If Point1.Visible=True Then Check4.Value=1
```

4. Press F5 to run the example.

Editable Shape Control

Description

Referring now to Figures 30 and 31, EditableShape is a Visual Basic custom control which provides two dimensional geometric shapes that can be interactively edited. Within an area 300 are located interactive sizing handles 302.

File Name

VISION.VBX

Object Type

EditableShape

Remarks

This custom control is like the Visual Basic Shape control but can be edited both at design time and by the end user at run-time. Furthermore, the user is able to interrogate the attributes of a shape such as its width, height, rotation etc. as illustrated at area 304.

Like the Visual Basic custom control: Shape, EditableShape can take the form of an ellipse, rectangle, circle, or square as illustrated at area 306. At Runtime it can be selected, rotated, moved, resized and "mutated" to another shape interactively by the use of a mouse as illustrated by shape editing options 307.

Like the Point custom control, the EditableShape can also be finely tuned using a similar toolbar. The centre button in the toolbar allows the user to change the fine-tune mode. By default, this is MOVEMODE (pressing the arrows will move the shape by one pixel in the relevant direction). The mode can also be ENLARGEMENT or SHRINKMODE. Pressing the arrows will cause the shape to be enlarged or shrunk by one pixel on the relevant corner of the shape's bounding rectangle.

The application programmer can prevent the user from moving, resizing, changing shape, rotating, selecting or fine-tuning an EditableShape by setting the appropriate property to False. Figure 31 illustrates popup menus 310 for run time shape editing.

Editable Shape Example Code

The example demonstrates features of an EditableShape custom control using a minimal user interface.

To use the example take the following steps:

1. Add the file VISION.VBX to a new Visual Basic project.
2. Create the User Interface:

- Place eight CheckBox controls on the default Visual Basic form. By default, the name of these controls should be Check1, Check 2,. . ., Check8.
- Give the following Captions to the controls just created.

Control	Caption
Check1	Show Direction Arrow
Check2	Enabled
Check3	Movable
Check4	Mutatable
Check5	Resizable
Check6	Rotatable
Check7	Tunable
Check8	Visible

- Place four OptionButton controls and give them the Name Option1. Answer yes when asked "Do you want to create a control array?". Give the controls the following captions:

Control	Caption
Option1(0)	Rectangle
Option1(1)	Square
Option1(2)	Oval
Option1(3)	Circle

- Place three labels on the form. The names of these Label controls should be Label1, Label2 and Label3.
- Place an Editable Shape custom control on the form, this should be named EditableShape1.

3. Add the code.

- Paste the following code in the Declarations section of the form:

```
Sub Check1_Click ()
EditableShape1.DirectionArrow=Check1.Value
End Sub
Sub Check2_Click ()
EditableShape1.Enabled = Check2.Value
UpdateCheckBoxes
End Sub
Sub Check3_Click ()
EditableShape1.Movable = Check3.Value
UpdateCheckBoxes
End Sub
Sub Check4_Click ()
EditableShape1.Mutatable = Check4.Value
UpdateCheckBoxes
End Sub
Sub Check4_Click ()
EditableShape1.Mutatable = Check4.Value
UpdateCheckBoxes
End Sub
Sub Check5_Click ()
EditableShape1.Resizable = Check5.Value
UpdateCheckBoxes
End Sub
Sub Check6_Click ()
EditableShape1.Rotatable = Check6.Value
UpdateCheckBoxes
End Sub
Sub Check7_Click ()
EditableShape1.Tunable = Check7.Value
UpdateCheckBoxes
```

```
End Sub
Sub Check8_Click ()
EditableShape1.Visible = Check8.Value
End Sub
Sub EditableShape1_Move ()
Label1.Caption = "CentreX=" &
EditableShape1.ShapeWidth & " ShapeH=" &
EditableShape1.ShapeHeight
Sub EditableShape1_Resize ()
Label2.Caption = "ShapeW=" &
EditableShape1.ShapeWidth & "ShapeH+" &
EditableShape1.ShapeHeight
End Sub
Sub EditableShape1_Rotate ()
Label3.Caption = "Angle =" &
EditableShape1.Roll
End Sub

Sub UpdateCheckBoxes ()
Check1.Value =
Abs(EditableShape1.DirectionArrow)
Check2.Value = Abs(EditableShape1.Enabled)
Check3.Value = Abs(EditableShape1.Movable)
Check4.Value = Abs(EditableShape1.Mutatable)
Check5.Value = Abs(EditableShape1.Resizable)
Check6.Value = Abs(EditableShape1.Rotatable)
Check7.Value = Abs(EditableShape1.Tunable)
Check8.Value = Abs(EditableShape1.Visible)
End Sub
```

- Add the following code in the default form's Load event:

```
UpdateCheckBoxes
Option1(EditableShape1.Shape.Value = True
```

- Add the following code to Option 1's Click event:

EditableShape1.Shape = Index

4. Press F5 to run the example.

Stage Control

Description

Referring now to Figure 32, the Stage control provides facilities to control multi-axis stage hardware. The Stage control can control stage hardware which moves in X, Y, and Z axes, and which rotates around each axis (roll, pitch and yaw). The stage can be moved to an arbitrary (X,Y,Z,roll,pitch,yaw) position, moved to a home position, and moved to a number of stored positions.

Various properties and methods allow the stage to be controlled. These properties and methods can be accessed at design time through a code interface and also at run time through an interactive graphical user interface at area 320.

The Graphical User Interface 320 provided to control the stage manually provides facilities to move the stage in X,Y and Z axes and to change the roll of the stage. The point in the X/Y plane corresponding to the roll axis of rotation can also be moved. A Home operation is also provided by home button 321.

File Name

VISION.VBX

Object Type

Stage

Remarks

Before the Stage control can be used, the control must first be linked to some particular type of stage hardware and at least one Editable Shape by setting the Stage and hStageShape properties.

To use the graphical interface 320, adjust the X (322), Y (323), Z (324), roll (325), Pitch and yaw scrollbars, or enter position values explicitly in the text boxes. Methods and properties can be accessed through a context sensitive popup menu. This menu can be accessed by clicking with the right mouse button on the stage control.

Error Messages, Stage Control

The following table lists the trappable errors for the Stage control.

Error number	Message explanation
32001	HIT_HARD_LIMIT Stage hit hard limit. This error is caused by attempting to move the stage beyond one of its hard limits.
32002	OUT_OF_BOUNDS Attempt to move stage out of bounds. This error is cause by attempting to move the stage outside its bounds, as specified by the hBoundsShape property.
32003	STILL_MOVING Attempt to move stage while still moving. This error is caused by attempting to move the stage while it is still moving.

32004	STAGE_NOT_DEFINED Attempt to move stage will still moving. This error is caused by trying to access the physical stage when the Stage property is not set.
32005	CALIBRATION_NOT_DEFINED A calibration must be defined. This error is caused by trying to access the physical stage when the hCalibration property is not set.
32006	STAGE_SHAPE_NOT_DEFINED A physical stage shape must be defined. This error is caused by trying to access the physical stage when the hStageShape property is not set.

Stage Control Example

Place a Stage control onto a Form, place two Editable Shape controls onto the Stage control 326 (to define stage shape and bounds), and then paste the following code into the declarations section of the form:

```
Sub Form_Load ()
Stage1.Stage = XYYStage1.hCtl
Stage1.hStageShape = Editable Shape1.hCtl
Stage1.hBoundsShape = EditableShape2.hCtl
a% = Stage1.Home
End Sub
Sub Form_Click ()
Stage1.DestinationX = 20
Stage1.DestinationY = 30
```

```
Stage1.Destination Roll = 45
Stage1.Move
End Sub
```

Stage Property, Stage Control

Description

Sets or returns the particular type of stage hardware. This property is not available at design time.

Visual Basic

[form.]Stage.Stage[= *stage&*]

Visual C++

pStage→GetNumProperty ("Stage")
pStage→SetNumProperty ("Stage", *pXYZCompanyStage*)

Remarks

This property may be set to the Stage property of an XYZCompanyStage Control, or from another source which provides a compatible property.

Data Type

Long.

hStageShape Property, Stage Control

Description

Sets or returns the shape of the stage. This property is not available at design time.

Visual Basic

[form.]Stage .hStageShape[= *hCtl&*]

Visual C++

pStage → GetNumProperty ("hStageShape")

pStage → SetNumProperty ("hStageShape", *hCtl*)

Remarks

This property should be set to the hCtl property of an Editable Shape Control. The graphical properties of the Editable Shape such as BorderColor can be set, but do not set the Shape, size, position or Roll properties of the Editable Shape, as these will be modified automatically by the State Control.

Data Type

Long.

Type1 Stage Control

Description

Referring to Figure 33, the Type1 Stage Control is a run-time invisible control which provide an implementation of the Stage property for use by the Stage Control. The Type1 Stage Control does not directly move the motors to move the table - this control provides properties, methods and events to enable the motors to be moved from top level application code, and yet allow the application to use the standard Stage Control.

File Name

VISION.VBX

Object Type

Type1Stage

Remarks

To use the Type1 Stage Control, set the Stage property of the Stage Control equal to the Stage property of the Type1 Stage Control at run time.

Type1 Stage Example

Place a Stage Control and an Type1 Stage Control (i.e., icon 330) onto a Form (to define the hardware and software interface to the Type1 stage), place two Editable Shape controls onto the Stage control, and then paste the following code into the declarations section of the form:

```
Sub Form_Load ()
Stage1.Stage = Type1Stage.hCtl
Stage1.hStageShape = EditableShape1.hCtl
Stage1.hBoundsShape = EditableShape2.hCtl
End Sub
```

Stage Property, Type1 Stage Control

Description

Returns a value which can be used for the Stage property of the Stage Control. This property is read-only at run time, not available at design time.

Visual Basic

[*form.*]*Type1Stage*.Stage

Visual C++

PType1Stage → GetNumProperty ("Stage")

Remarks

Set the Stage property of the Stage Control equal to this property at run time.

Data Type

Long.

Type2 Stage Control

Description

The Type2 Stage Control is a run-time invisible control which provide an implementation of the Stage property for use by the Stage Control.

File Name

VISION.VBX

Object Type

Type2Stage

Remarks

To use the Type2 Stage Control, set the Stage property of the Stage Control equal to the Stage property of the Type2 Stage Control at run time.

Type2 Stage Example

Place a Stage Control and an Type2 Stage Control onto a Form, place two Editable Shape controls onto the Stage control, and then paste the following code into the declarations section of the form:

```
Sub Form_Load ()
Stage1.Stage=Type2Stage1.hCtl
Stage1.hStageShape=EditableShape1.hCtl
```

```
Stage1.hBoundsShape=EditableShape2.hCtl
End Sub
```

Stage Property, Type2 Stage Control

Description

Returns a value which can be used for the Stage property of the Stage Control. This property is read-only at run time, not available at design time.

Visual Basic

[form.]Type2Stage.Stage

Visual C++

pType2Stage → GetNumProperty ("Stage")

Remarks

Set the Stage property of the Stage Control equal to this property at run time.

Date Type

Long.

Type3 Stage Control

Description

The Type3 Stage Control is a run-time invisible control which provide an implementation of the Stage property for use by the Stage Control.

File Name

VISION.VBX

Object Type

Type3Stage.

Remarks

To use the Type3 Stage Control, set the Stage property of the Stage Control equal to the Stage property of the Type3 Stage Control at run time.

Type3 Stage Example

Place a Stage Control and a Type3 Stage Control onto a Form, place two Editable Shape controls onto the Stage control, and then paste the following code into the declarations section of the form:

```
Sub Form_Load ()
Stage1.Stage=Type3Stage1.hCtl
Stage1.hStageShape=EditableShape1.hCtl
Stage1.hBoundsShape=EditableShape2.hCtl
End Sub
```

Stage Property, Type3 Stage Control

Description

Returns a value which can be used for the Stage property of the Stage Control. This property is read-only at run time, not available at design time.

Visual Basic

[*form.*]*Type3Stage*.Stage

Visual C++

pType3Stage→GetNumProperty ("Stage")

Remarks

Set the Stage property of the Stage Control equal to this property at run time.

Data Type

Long.

Toolbar Control

Description

The Toolbar control allows you to create a context-sensitive toolbar for navigating the windows and menus in the application using simple button clicks. It is generally used as a graphical replacement for the main menu bar of the application. Buttons for window selection, sub-window selection and popup menu selection can be added to the toolbar, as well as custom buttons for specific commands. Custom buttons may be volatile, i.e. appearing only in a specific context, or fixed, i.e. always visible. Some predefined fixed buttons are provided for common commands such as Help, Undo, Print, Save, Open, and Exit. The route taken through the menu levels to the current menu is shown at the tope of the toolbar, providing a visual reminder of the route and also allowing the user to instantly jump back to any level.

File Name

VISION.VBX

Object Type

Toolbar

Remarks

To add any type of button you must first set the Button Type property.

To add window selection buttons to the toolbar, you must set the WindowIndex property, and then set the WindowhWnd property. This must be done at run-time. Buttons for sub-windows and popup menus may be similarly added.

To add a popup menu to the toolbar you must set the Windowindex property, set the SubWindowIndex property, and then set the WindowhMenu property. The SubWindow must be previously defined.

To add a custom fixed command button, set the ButtonIndex property to an unused button index, and set the ButtonPicture and ButtonCaption properties. This may be done only at run time.

Predefined fixed command buttons such as the Help button may be enabled/disabled by setting the appropriate Visible property to True, eg. HelpButtonVisible.

To add a custom volatile command button, use the WindowIndex and SubWindowIndex properties to navigate to the desired context, set the ButtonIndex property to an unused button index, and set the ButtonPicture and ButtonCaption properties. This may be done only at run time.

Default captions are generated for each button but may be overridden. For example, to change the default caption for a window selection button, set the ButtonType property, set the WindowIndex property to the desired window, and then set the ButtonCaption property. This may be done only at run time.

ButtonType Property, Toolbar Control

Description

Sets the type of the buttons.

Visual Basic

[form.]Toolbar.ButtonType[={Fixed|Volatile|Popup|Window}]

Visual C++

pToolbar→SetNumProperty("ButtonType",{Fixed|Volatile|Popup|Window})

Remarks

Fixed buttons are always visible at the right hand end of the toolbar. Volatile buttons are attached to a particular window or sub window, visible only when the buttons for that particular window are visible. All Volatile buttons defined for one menu are kept in all the submenus.

Data Type

Integer

WindowIndex, SubWindowIndex Properties, Toolbar Control

Description

Sets or returns the currently selected window or sub-window.

Visual Basic

[form.]Toolbar.ButtonType[={Window}]
[form.]Toolbar.WindowIndex[=index%]
[form.]Toolbar.SubWindowIndex]

Visual C++

```
pToolbar->SetNumProperty("ButtonType",{WINDOW})
pToolbar->SetNumProperty("WindowIndex"),index)
pToolbar->SetNumProperty("SubWindowIndex",
index)
```

Remarks

The window index and sub-window index can be used to both set and get the currently selected windows. The indexes are numbered from zero, -1 means no current selection. It is necessary to set the indexes in order to add new windows and menus to the structure of the toolbar, and also to override default button captions.

Data Type

Integer.

WindowhMenu Property, Toolbar Control

Description

Sets or returns the hMenu of the popup menu of the currently selected window or sub-window. Not available at design time.

Visual Basic

```
[form.]Toolbar.ButtonType[={Window}]
[form.]Toolbar.WindowIndex[=index%]
[form.]Toolbar.SubWindowIndex[=index%]
[form.]Toolbar.WindowhMenu[=handle%]
```

Visual C++

```
pToolbar->SetNumProperty("ButtonType",{WINDOW})
pToolbar->SetNumProperty("WindowIndex",index)
pToolbar->SetNumProperty("SubWindowIndex",
```

index)
pToolbar→GetNumProperty("WindowhMenu")
pToolbar→SetNumProperty("WindowhMenu",*handle*)

Remarks

When a popup menu is added to the toolbar, a button is added for each menu option and each submenu option. By default, the caption is taken from the menu itself.

To add a new popup menu set of buttons to the toolbar, set the ButtonType property, set the WindowIndex property to the appropriate window index number, set SubWindowIndex to the appropriate window index number, and then set the WindowhMenu property to the HMENU of the popup menu.

Data Type

Integer.

ButtonIndex Property, Toolbar Control

Description

Sets or returns the current volatile/fixed/popup button index.

Visual Basic

[*form.*]*Toolbar*.ButtonType[={Fixed|Volatile|Popup|Window}]
[*form.*]*Toolbox*.ButtonIndex[=index%]

Visual C++

pToolbar→SetNumProperty("ButtonType",{FIXED|VOLATILE|POPUP|WINDOW})
pToolbar→SetNumProperty("ButtonIndex",*index*)

Remarks

The button index must be set in order to override default button captions. Button indexes for volatile or fixed buttons are numbered from zero onwards.

To change the default caption for a menu item, set the Button Type property, set the ButtonIndex property to the index of the desired button, then set the ButtonCaption and/or ButtonPicture properties.

Data Type

Integer.

ButtonPicture Property, Toolbar Control

Description

Specifies a bitmap to display on a button/window.

Visual Basic

```
[form.]Toolbar.ButtonType[={Fixed|Volatile|
Popup}]
[form.]Toolbar.ButtonIndex=index%
[form.]Toolbar.ButtonPicture[=picture]

[form.]Toolbar.ButtonType[={Window}]
[form.]Toolbar.WindowIndex=index%
[form.]Toolbar.SubWindowIndex=index%
[form.]Toolbar.ButtonPicture[=picture]
```

Visual C++

```
pToolbar->SetNumProperty("ButtonType",{FIXED|
VOLATILE|POPUP})
pToolbar->SetNumProperty("ButtonIndex",index)
```

```
pToolbar->GetNumProperty("ButtonPicture")
pToolbar->SetNumProperty("ButtonPicture",
picture)
pToolbar->SetNumProperty("ButtonType",{WINDOW})
pToolbar->SetNumProperty("WindowIndex",index)
pToolbar->SetNumProperty("SubWindowIndex",
index)
pToolbar->GetNumProperty("ButtonPicture")
pToolbar->SetNumProperty("ButtonPicture",
picture)
```

Data Type

Integer.

ButtonCaption Property, Toolbar Control

Description

Specifies a caption to display on a button.

Visual Basic

```
[form.]Toolbar.ButtonType[={Fixed|Popup|
Window}]
[form.]Toolbar.ButtonIndex=index%
[form.]Toolbar.ButtonCaption[=caption$]
```

Visual C++

```
pToolbar->SetNumProperty("ButtonType",{FIXED|
VOLATILE|POPUP|WINDOW})
pToolbar->SetNumProperty("ButtonIndex",index)
pToolbar->GetNumProperty("ButtonCaption")
pToolbar->SetNumProperty("ButtonCaption",
caption)
```

Remarks

The popup menu button captions default to the captions that appear in the popup menu. Use the ButtonCaption property to override this caption.

Data Type

Integer.

ExitButtonVisible HelpButtonVisible, OkButtonVisible, CancelButtonVisible,PrintButtonVisible,SaveButton Visible,OpenButtonVisible, UndoButtonVisible, NextButtonVisible,PreviousButtonVisible Properties, Toolbar Control

Description

Determines if a predefined fixed button is visible or invisible at run time.

Visual Basic

[*form.*]*Toolbar*.HelpButtonVisible[= {True|False}]
[*form.*]*Toolbar*.UndoButtonVisible[= {True|False}]
[*form.*]*Toolbar*.PrintButtonVisible[= {True|False}]
[*form.*]*Toolbar*.OpenButtonVisible[= {True|False}]
[*form.*]*Toolbar*.SaveButtonVisible[= {True|False}]
[*form.*]*Toolbar*.ExitButtonVisible[= {True|False}]
[*form.*]*Toolbar*.OkButtonVisible[= {True|False}]
[*form.*]*Toolbar*.CancelButtonVisible[= {True|False}]
[*form.*]*Toolbar*.NextButtonVisible[=

```
{True|False}]
[form.]Toolbar.PreviousButtonVisible[=
{True|False}]
```

Visual C++

```
pToolbar->GetNumProperty("HelpButtonVisible")
pToolbar->SetNumProperty("HelpButtonVisible",
{TRUE|FALSE})
pToolbar->GetNumProperty("UndoButtonVisible")
pToolbar->SetNumProperty("UndoButtonVisible",
{TRUE|FALSE})
pToolbar->GetNumProperty("PrintButtonVisible")
pToolbar->SetNumProperty("PrintButtonVisible",
{TRUE|FALSE})
pToolbar->GetNumProperty("OpenButtonVisible")
pToolbar->SetNumProperty("OpenButtonVisible",
{TRUE|FALSE})
pToolbar->GetNumProperty("SaveButtonVisible")
pToolbar->SetNumProperty("SaveButtonVisible",
{TRUE|FALSE})
pToolbar->GetNumProperty("ExitButtonVisible")
pToolbar->SetNumProperty("ExitButtonVisible",
{TRUE|FALSE})
pToolbar->GetNumProperty("OkButtonVisible")
pToolbar->SetNumProperty("OkButtonVisible",
{TRUE|FALSE})
pToolbar->GetNumProperty("CancelButtonVisible")
pToolbar->SetNumProperty("CancelButtonVisible",
{TRUE|FALSE})
pToolbar->GetNumProperty("NextButtonVisible")
pToolbar->SetNumProperty("NextButtonVisible",
{TRUE|FALSE})
pToolbar->GetNumProperty("PreviousButton
Visible")
```

pToolbar→SetNumProperty("PreviousButton Visible",{TRUE|FALSE})

Remarks

The predefined fixed buttons appear in the right hand end fixed section of the toolbar. They have predefined captions, and generate predefined events, such as Help Click.

Data Type

Integer(Boolean).

WindowIndex, SubWindowIndex Properties, Toolbar Control

Description

Sets or returns the currently selected window or sub-window.

Visual Basic

[*form.*]*Toolbar*.ButtonType[={Window}]
[*form.*]*Toolbar*.WindowIndex[=index%]
[*form.*]*Toolbar*.SubWindowIndex[=index%]

Visual C++

pToolbar→SetNumProperty("ButtonType",{WINDOW})
pToolbar→SetNumProperty("WindowIndex",*index*)
pToolbar→SetNumProperty("SubWindowIndex", *index*)

Remarks

The window index and sub-window index can be used to both set and get the currently selected windows. The indexes are numbered from zero, -1 means no current selection. It is necessary to set the indexes in order

to add new windows and menus to the structure of the toolbar, and also to override default button captions.

Data Type

Integer.

While the best mode for carrying out the invention has been described in detail, those familiar with the art to which this invention relates will recognize various alternative designs and embodiments for practicing the invention as defined by the following claims.

What Is Claimed Is:

1. A method for quickly developing application software for use in a machine vision system using a computer system, the method comprising the steps of:

storing an application development program, including a first set of custom control programs representing possible components of a user interface for the machine vision system, the first set of custom control programs defining a first set of custom controls;

storing a second set of custom control programs representing possible machine vision algorithms for the machine vision system, the second set of custom control programs defining a second set of custom controls;

storing hardware operating parameters corresponding to possible hardware for use in the machine vision system, the hardware operating parameters defining a third set of custom controls;

displaying a graphical representation of the possible components, the possible hardware and the possible machine vision algorithms;

receiving commands from a user of the computer system to select a first custom control program corresponding to a desired component of the user interface desired hardware operating parameters corresponding to desired hardware and a second custom control program corresponding to a desired machine vision algorithm; and

linking the first custom control program with the desired hardware operating parameters to the second custom control program to form the application software in response to the commands.

2. The method as claimed in claim 1 wherein the custom controls include properties and wherein the step of linking includes the step of setting the properties of the custom controls.

3. The method as claimed in claim 2 wherein the step of setting includes the step of setting one property of one custom control to be equal to one property of another custom control.

4. The method as claimed in claim 1 wherein the step of linking includes the step of receiving a set of instructions from the user of the computer system.

5. The method as claimed in claim 1 further comprising the steps of:

storing a third set of custom control programs representing possible software products for use in a machine vision system; and

displaying a graphical representation of the possible software products, wherein the step of linking links a third custom control program corresponding to a desired software product with the first and second custom control programs and the desired hardware operating parameters in response to the commands to form the application software.

6. The method as claimed in claim 1 wherein the desired hardware operating parameters correspond to a desired image source of the machine vision system.

7. The method as claimed in claim 6 wherein the desired image source is a video camera.

8. The method as claimed in claim 6 wherein the desired operating parameters further correspond to a desired vision processor board of the machine vision system.

9. The method as claimed in claim 6 wherein the desired hardware operating parameters further correspond to a desired frame grabber board of the machine vision system.

10. The method as claimed in claim 6 wherein the desired hardware operating parameters further correspond to a desired motion board of the machine vision system.

11. The method as claimed in claim 6 wherein the desired hardware operating parameters further correspond to a desired bus of the machine vision system.

12. The method as claimed in claim 6 wherein the desired machine vision algorithm is an image processing algorithm.

13. The method as claimed in claim 6 wherein the desired machine vision algorithm is an image-analysis algorithm.

14. The method as claimed in claim 6 wherein the desired machine vision algorithm is a calibration space algorithm.

15. The method as claimed in claim 6 wherein the desired machine vision algorithm is an interactive CAD/geometry algorithm.

16. The method as claimed in claim 6 wherein the computer system includes a personal computer.

17. A computer system for quickly developing application software for use in a machine vision system, the system comprising:

means for storing an application development program, including a first set of custom control programs representing possible components of a user interface for the machine vision system, the first set of custom control programs defining a first set of custom controls;

means for storing a second set of custom control programs representing possible machine vision algorithms for the machine vision system, the second set of custom control programs defining a second set of custom controls;

means for storing hardware operating parameters corresponding to possible hardware for use in the machine vision system, the hardware operating parameters defining a third set of custom controls;

means for displaying a graphical representation of the possible components, the possible hardware and the possible machine vision algorithms;

means for receiving commands from a user of the computer system to select a first custom control program corresponding to a desired component of the user interface, desired hardware operating parameters corresponding to desired hardware and a second custom control

program corresponding to a desired machine vision algorithm; and

means for linking the first custom control program with the desired hardware operating parameters to the second custom control program to form the application software in response to the commands.

18. The computer system as claimed in claim 17 wherein the custom controls include properties and wherein the means for linking includes means for setting the properties of the custom controls.

19. The computer system as claimed in claim 18 wherein the step of setting includes the step of setting one property of one custom control to be equal to one property of another custom control.

20. The computer system as claimed in claim 17 wherein the step of linking includes the step of receiving a set of instructions from the user of the computer system.

21. The computer system as claimed in claim 17 further comprising:

means for storing a third set of custom control programs representing possible software products for use in a machine vision system; and

means for displaying a graphical representation of the possible software products, wherein the step of linking links a third custom control program corresponding to a desired software product with the first and second custom control programs and the desired hardware operating parameters in response to the commands to form the application software.

22. The computer system as claimed in claim 17 wherein the desired hardware operating parameters correspond to a desired image source of the machine vision system.

23. The computer system as claimed in claim 22 wherein the desired image source is a video camera.

24. The computer system as claimed in claim 22 wherein the desired operating parameters further correspond to a desired vision processor board of the machine vision system.

25. The computer system as claimed in claim 22 wherein the desired hardware operating parameters further correspond to a desired frame grabber board of the machine vision system.

26. The computer system as claimed in claim 22 wherein the desired hardware operating parameters further correspond to a desired motion board of the machine vision system.

27. The computer system as claimed in claim 22 wherein the desired hardware operating parameters further correspond to a desired bus of the machine vision system.

28. The computer system as claimed in claim 22 wherein the desired machine vision algorithm is an image processing algorithm.

29. The computer system as claimed in claim 22 wherein the desired machine vision algorithm is an image-analysis algorithm.

30. The computer system as claimed in claim 22 wherein the desired machine vision algorithm is a calibration space algorithm.

31. The computer system as claimed in claim 22 wherein the desired machine vision algorithm is an interactive CAD/geometry algorithm.

32. The computer system as claimed in claim 22 wherein the computer system includes a personal computer.

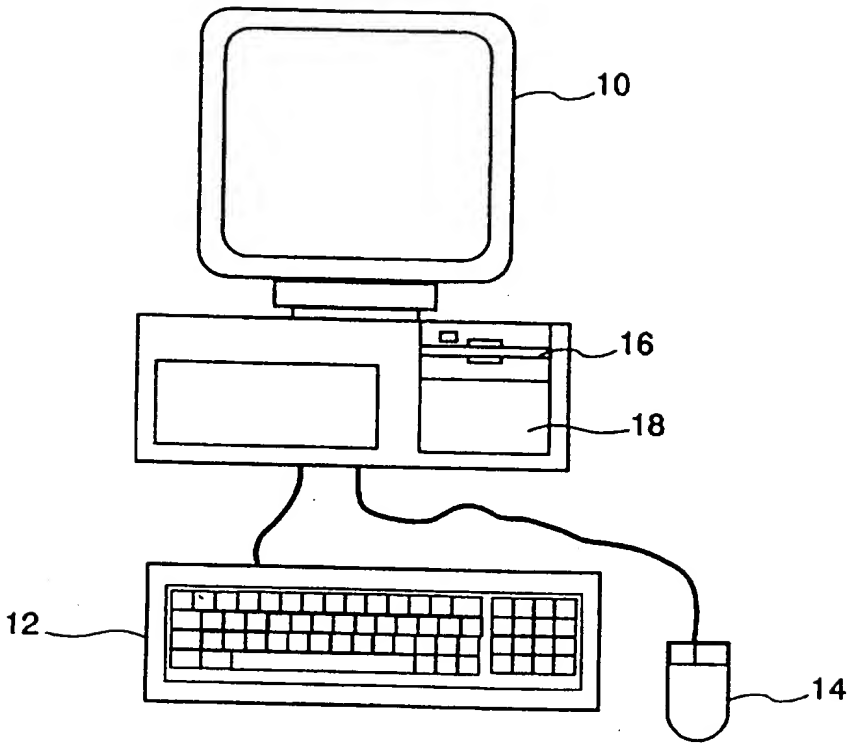

Fig. 1

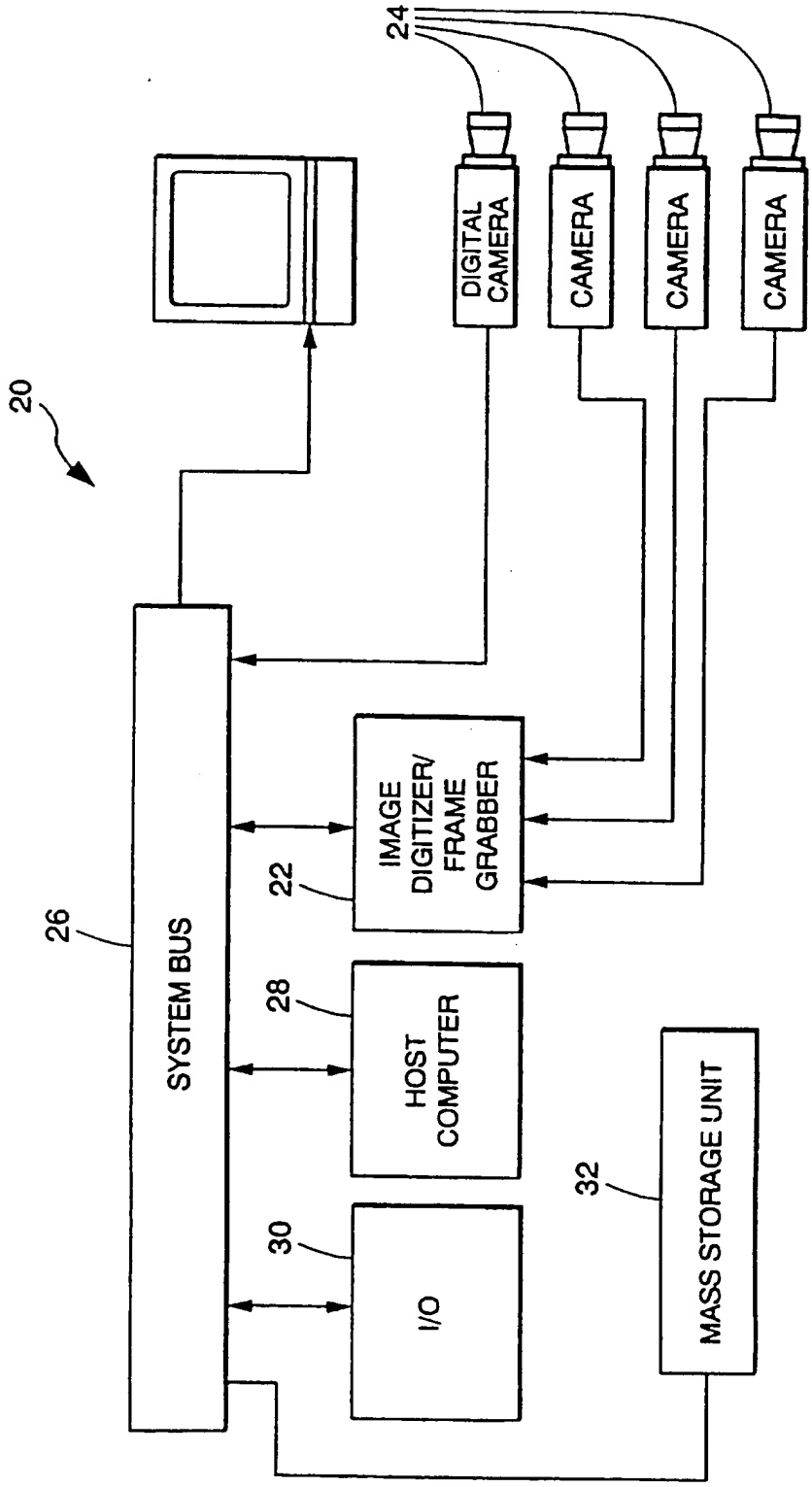
24
DIGITAL CAMERA
CAMERA
CAMERA
CAMERA
20
IMAGE DIGITIZER/ FRAME GRABBER
22
26
SYSTEM BUS
28
HOST COMPUTER
30
I/O
32
MASS STORAGE UNIT

Fig. 2

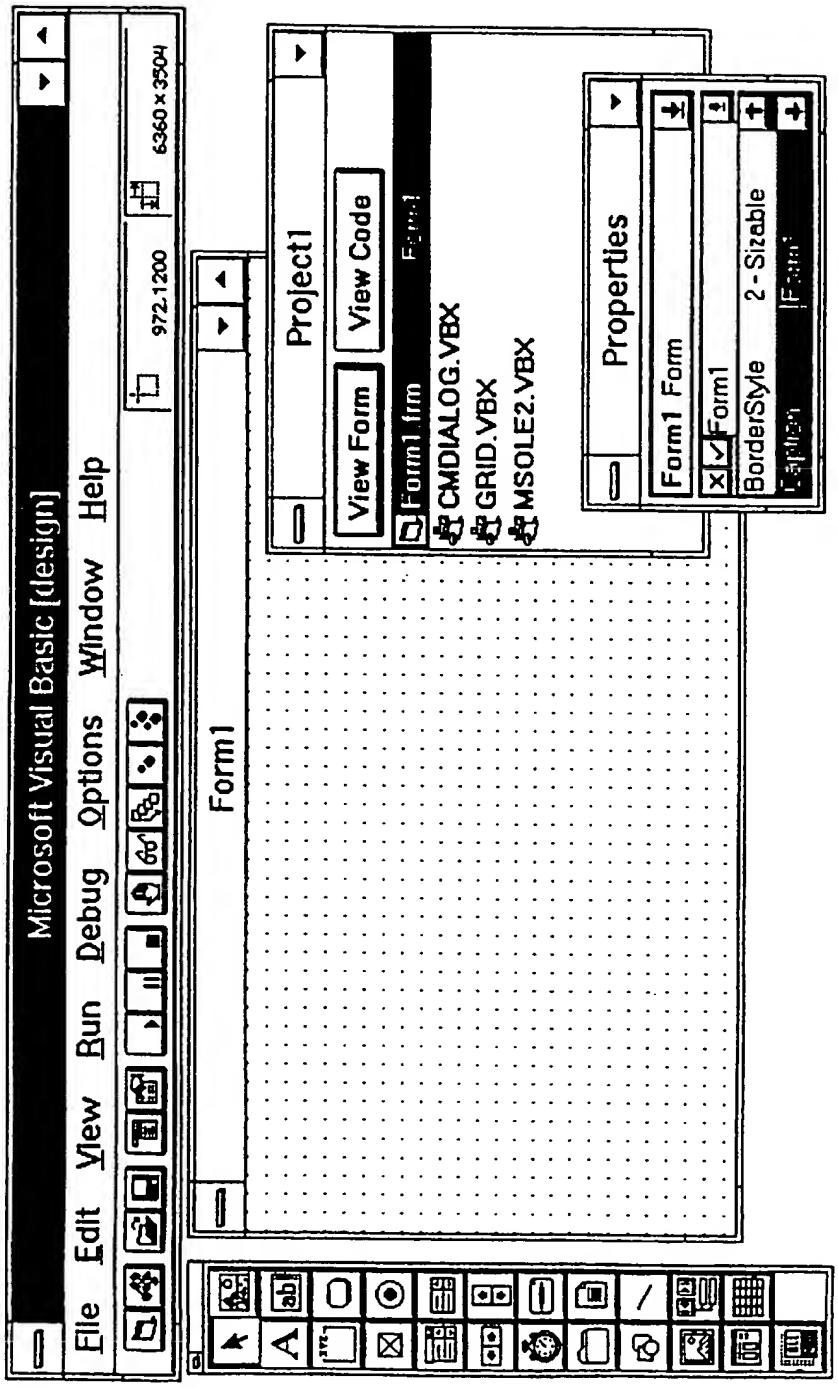
Microsoft Visual Basic [design]
File Edit View Run Debug Options Window Help
972,1200
6360 x 3504
Form1
Project1
View Form
View Code
Form1.frm
CMDIALOG.VBX
GRID.VBX
MSOLE2.VBX
Properties
Form1 Form
Form1
BorderStyle
2 - Sizable

Fig. 3

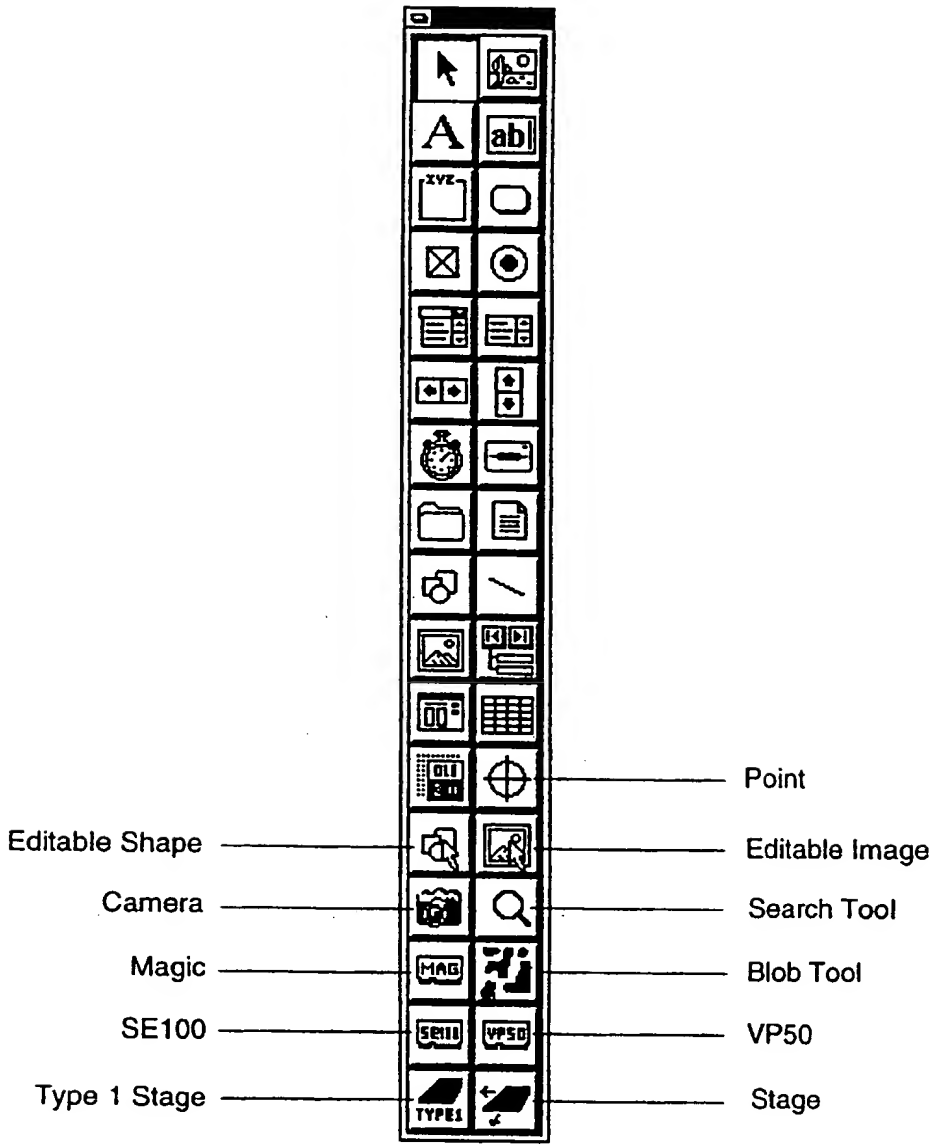
Point
Editable Shape
Editable Image
Camera
Search Tool
Magic
Blob Tool
SE100
VP50
Type 1 Stage
Stage
MAG
SE100
VP50
TYPE1

Fig. 4

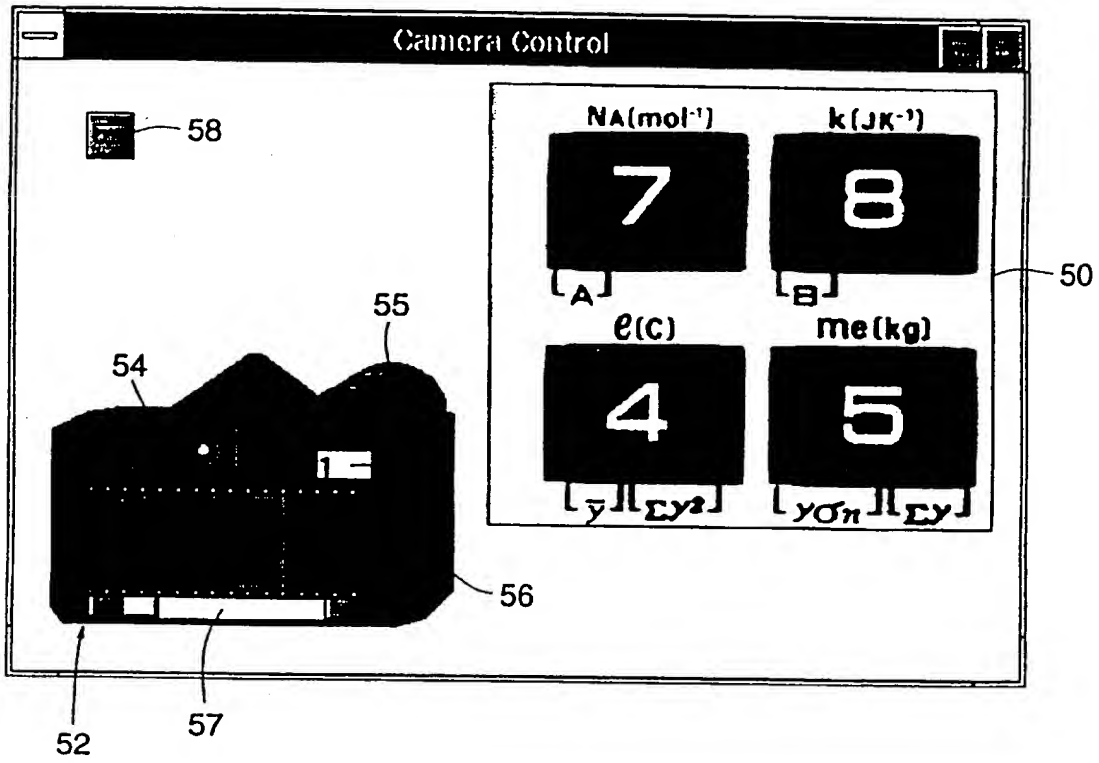
Camera Control
58
NA(mol⁻¹)
k(JK⁻¹)
7
8
A
B
50
55
54
e(C)
me(kg)
4
5
ȳ
Σy²
yσn
Σy
56
52
57

Fig. 5

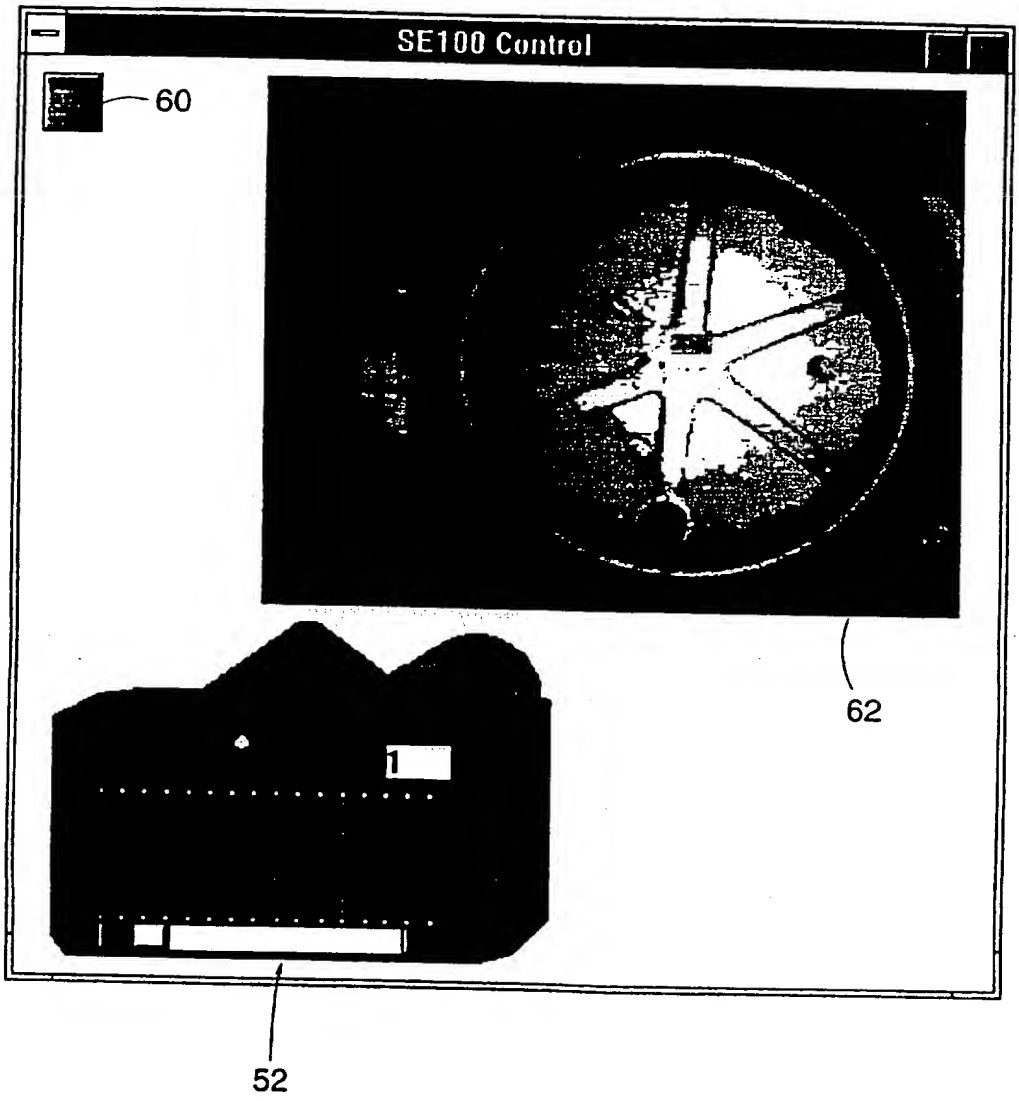

Fig. 6

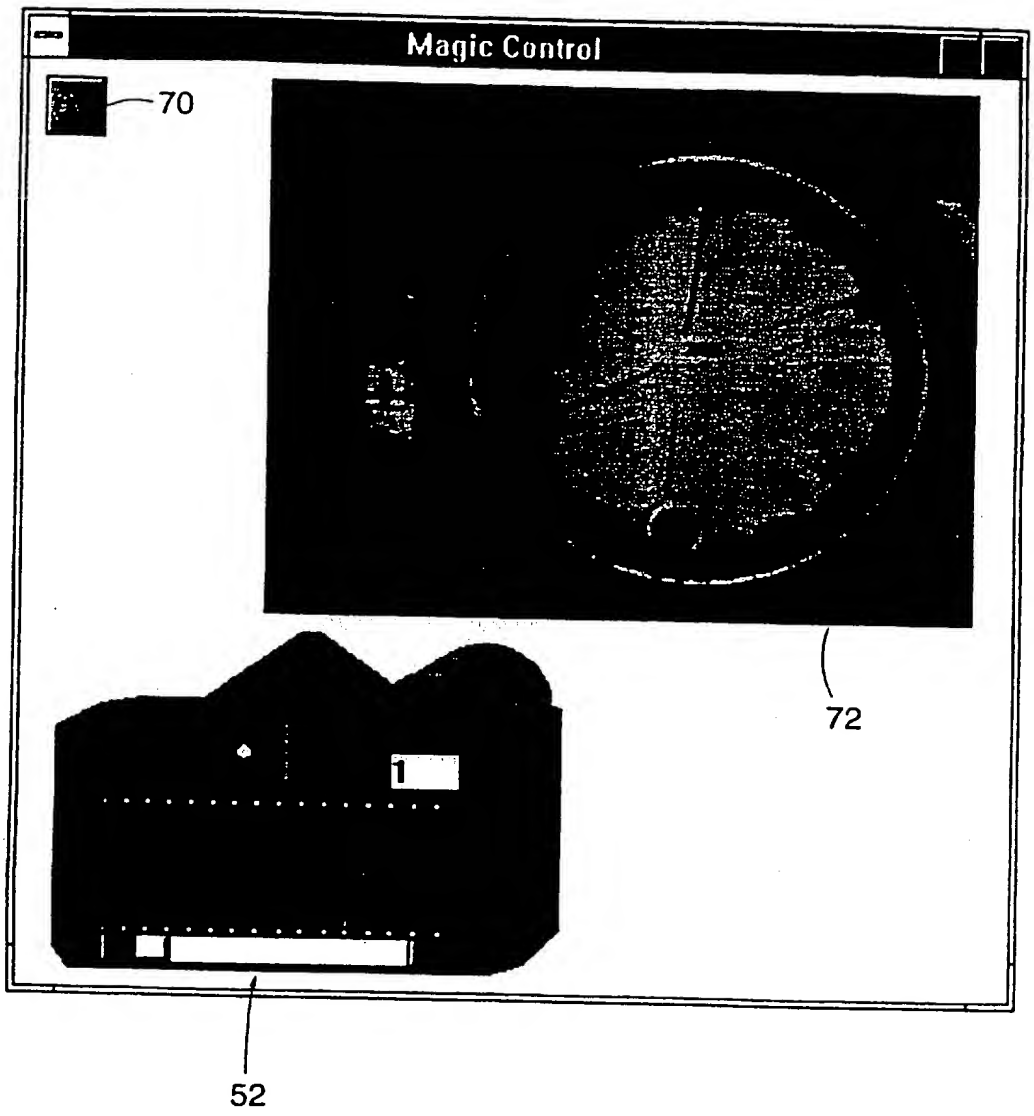

Fig. 7

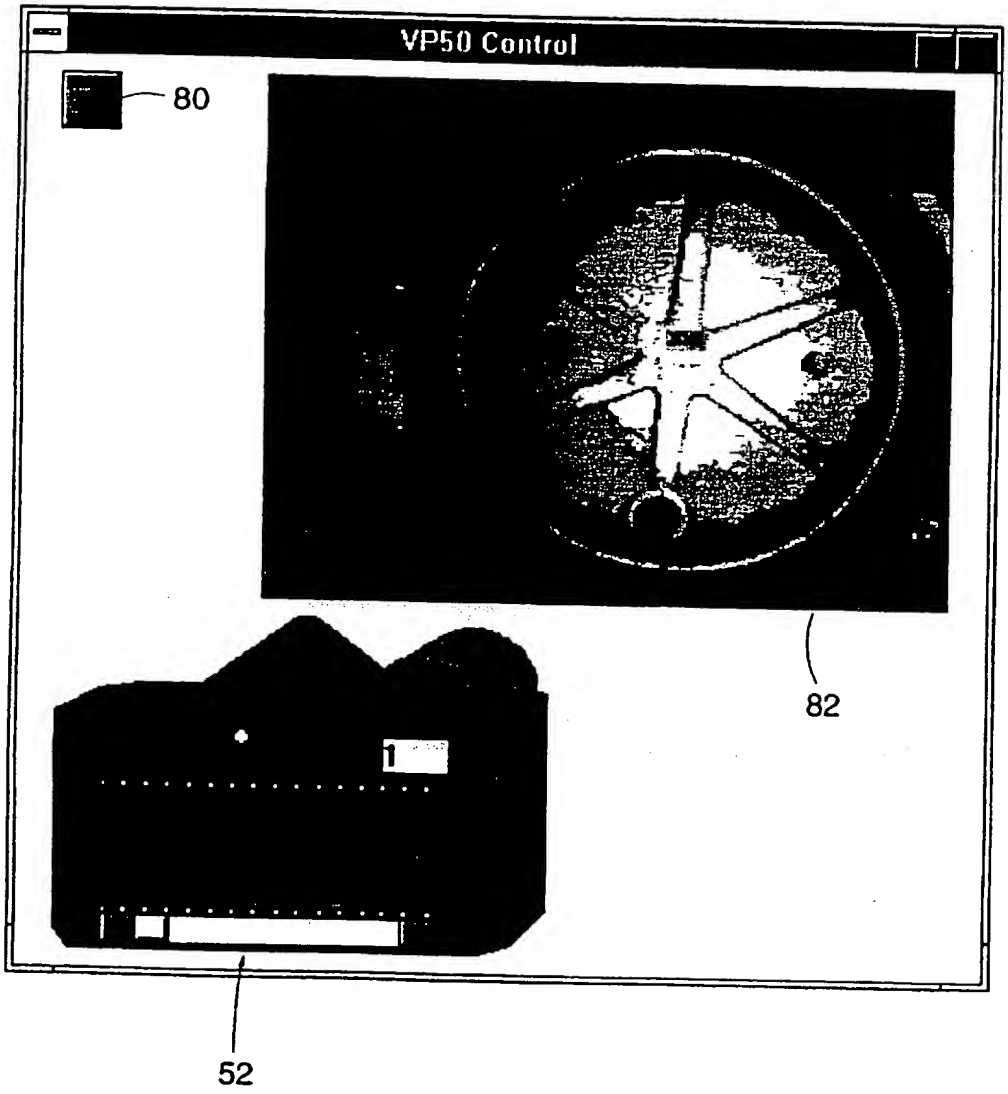

Fig. 8

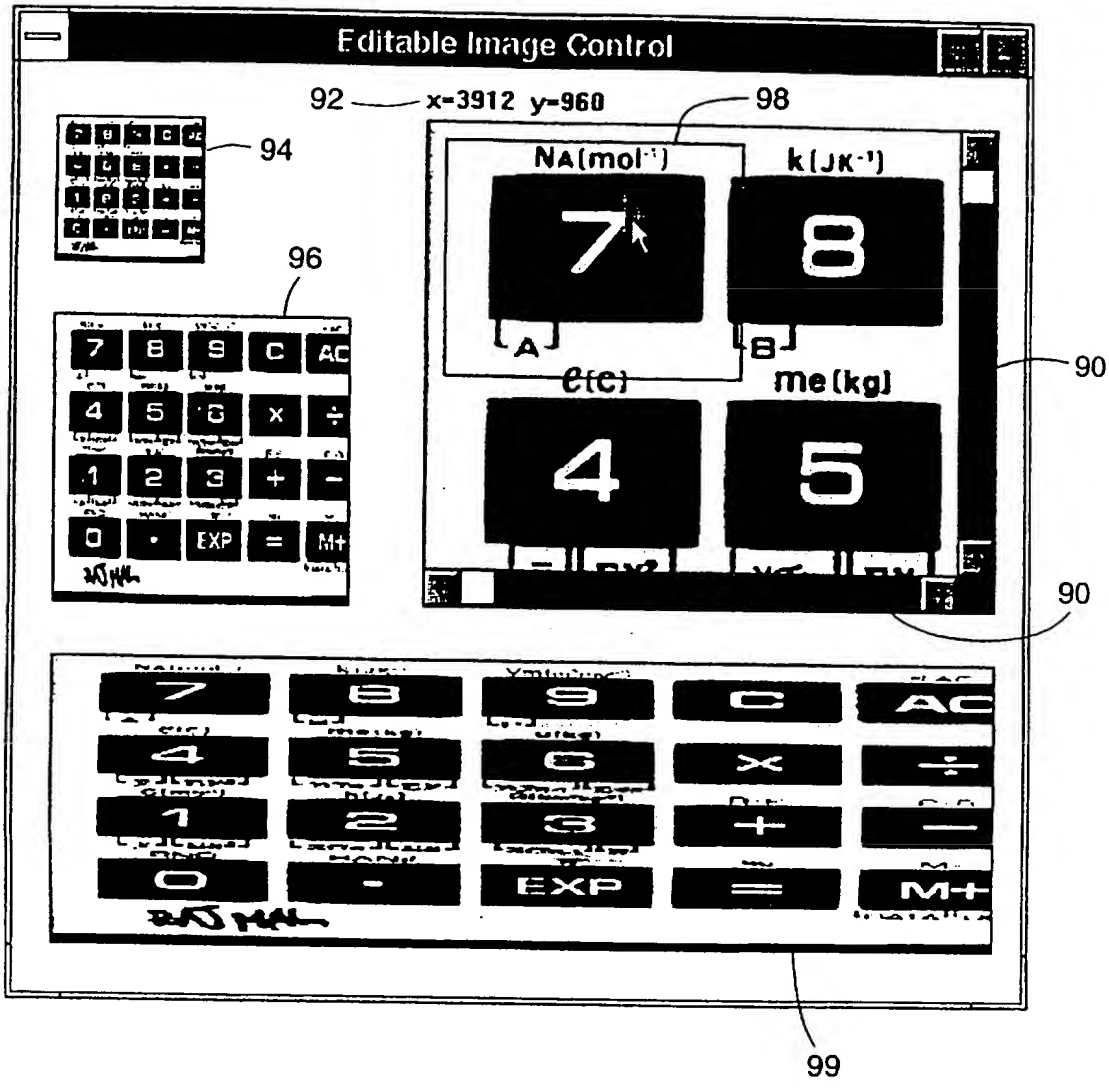
Editable Image Control
92
x=3912 y=960
98
94
96
NA(mol⁻¹)
k(JK⁻¹)
7
8
A
B
e(c)
me(kg)
4
5
90
90
99

Fig. 9

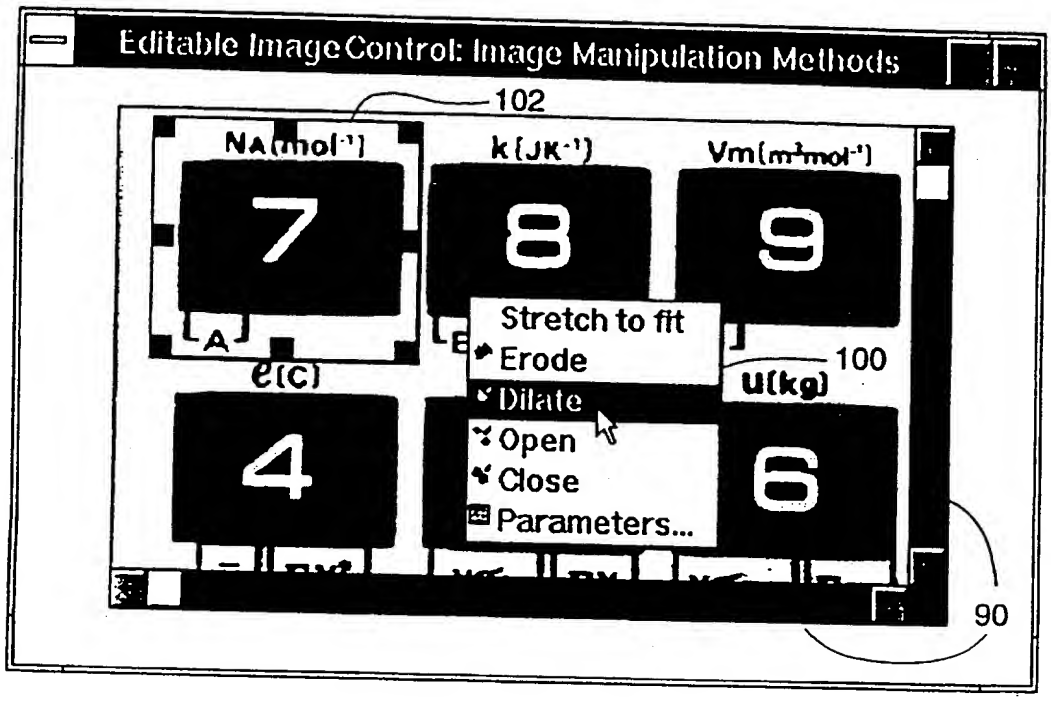
Editable Image Control: Image Manipulation Methods
102
NA(mol-1)
k(JK-1)
Vm(m3mol-1)
7
8
9
A
e(C)
Stretch to fit
Erode
Dilate
Open
Close
Parameters...
100
U(kg)
4
6
90

Fig. 10

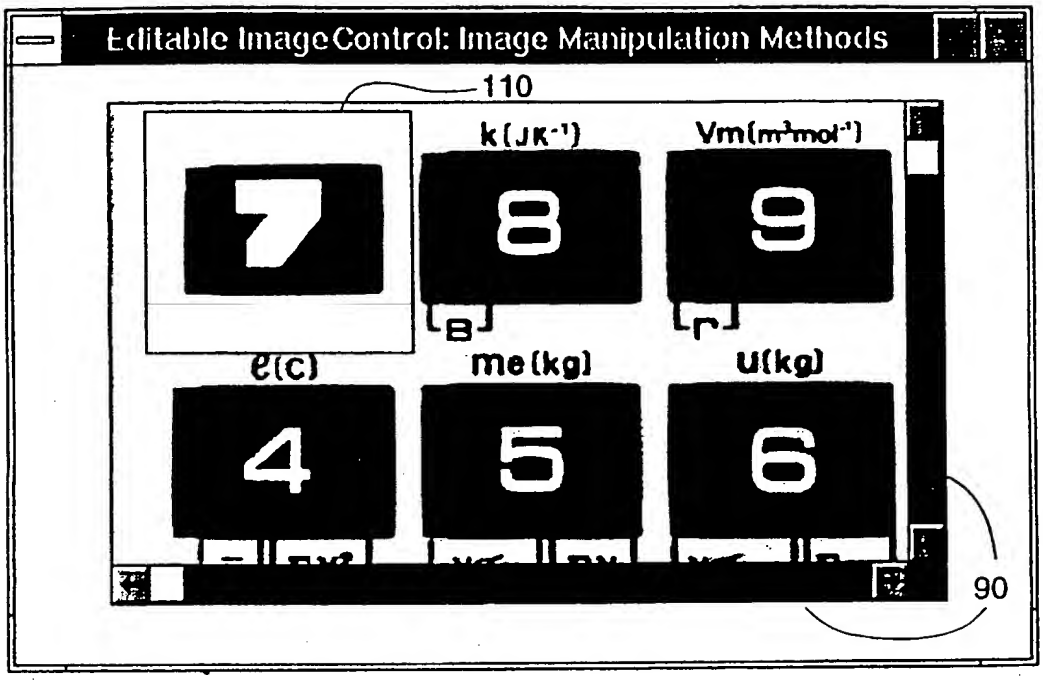
Editable Image Control: Image Manipulation Methods
110
k(JK⁻¹)
Vm(m³mol⁻¹)
7
8
9
e(C)
me(kg)
u(kg)
4
5
6
90

Fig. 11

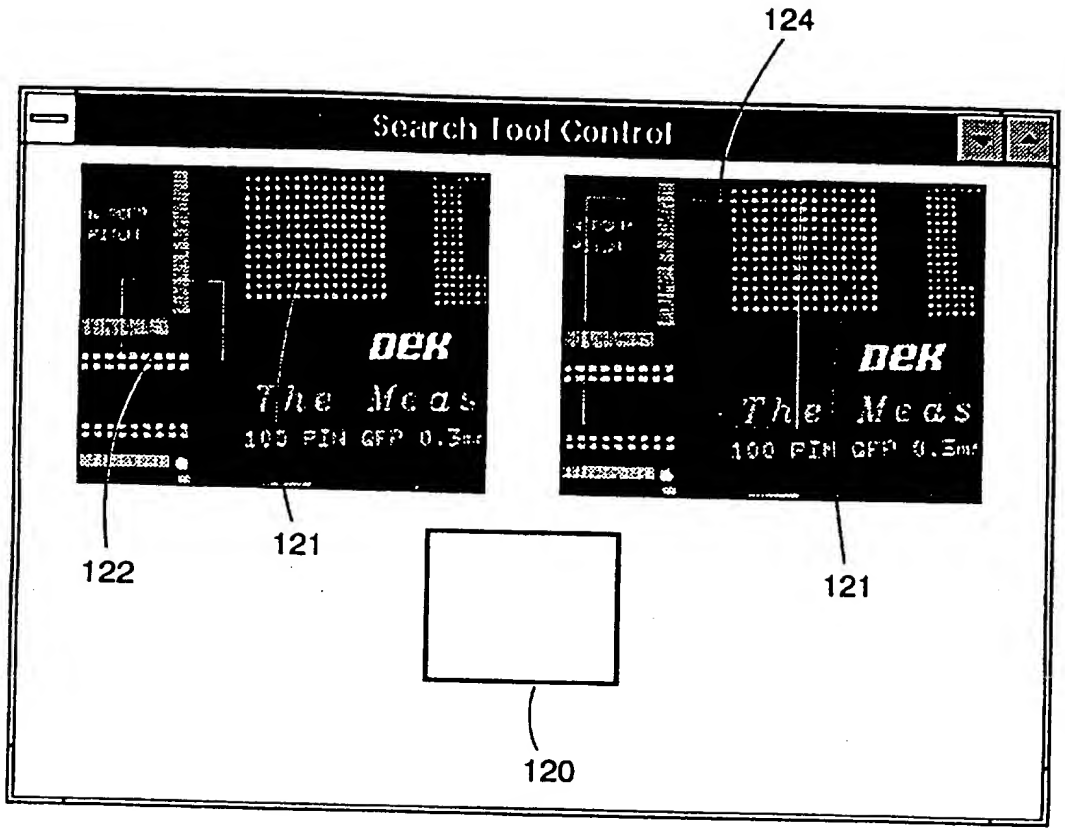

Fig. 12

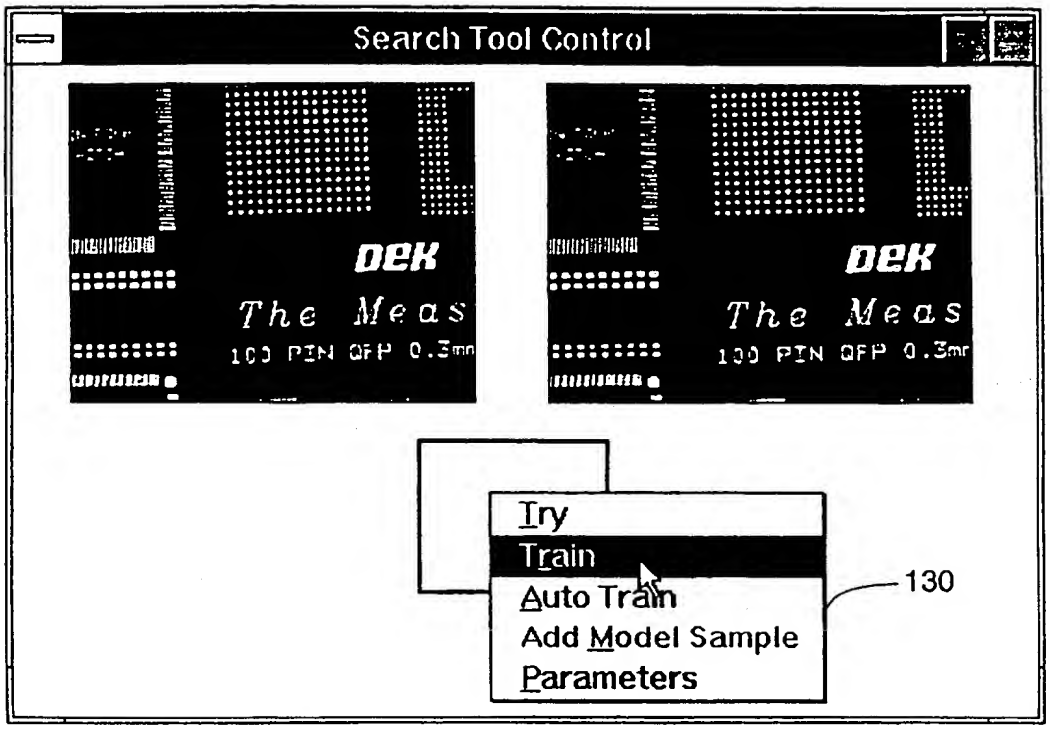
Search Tool Control
Try
Train
Auto Train
Add Model Sample
Parameters
130

Fig. 13

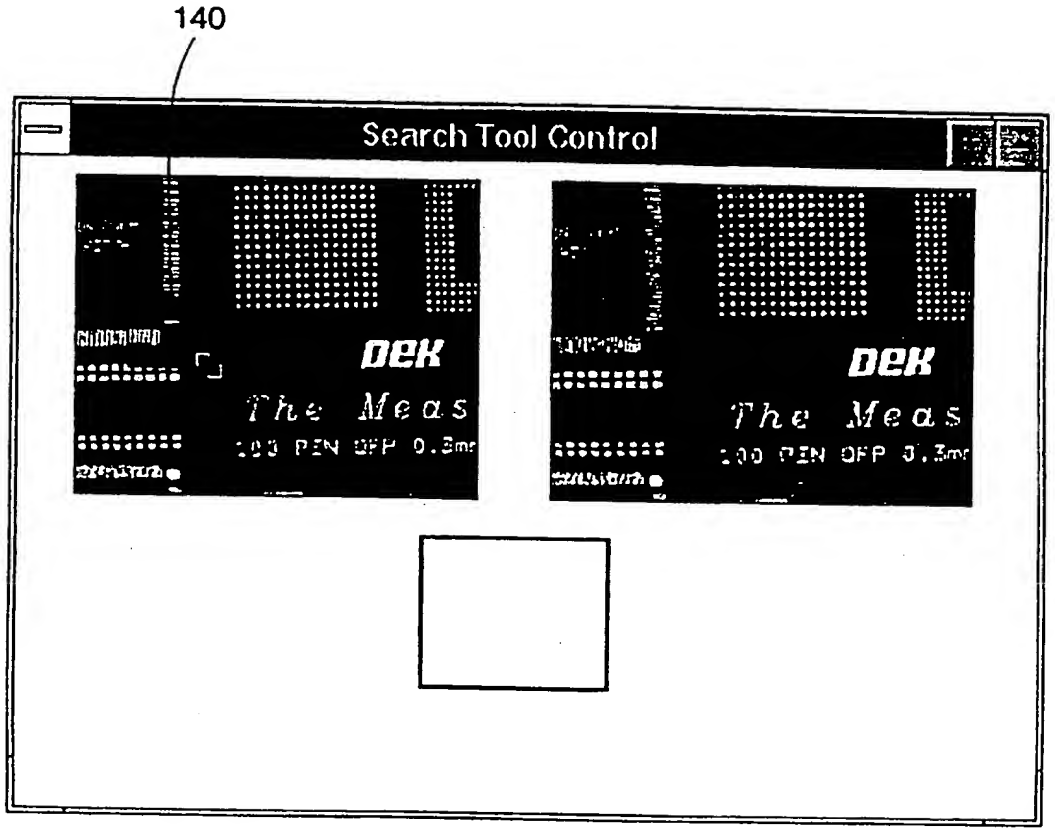

Fig. 14

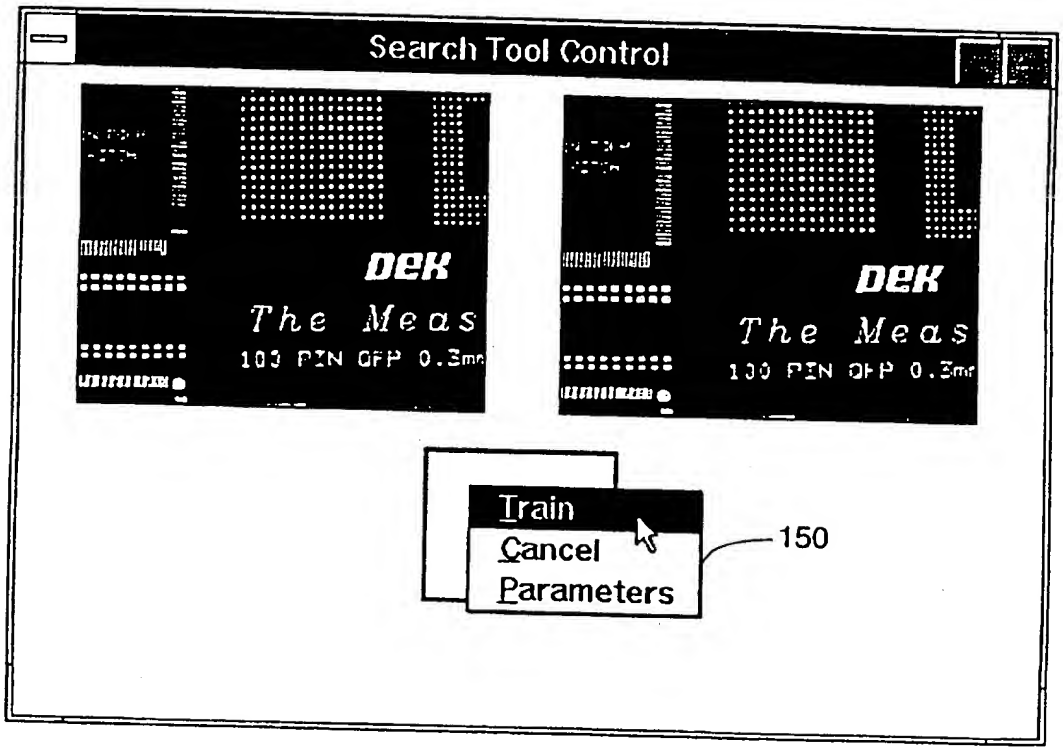
Search Tool Control
DEK
The Meas
100 PIN QFP 0.3mm
DEK
The Meas
100 PIN QFP 0.3mm
Train
Cancel
Parameters
150

Fig. 15

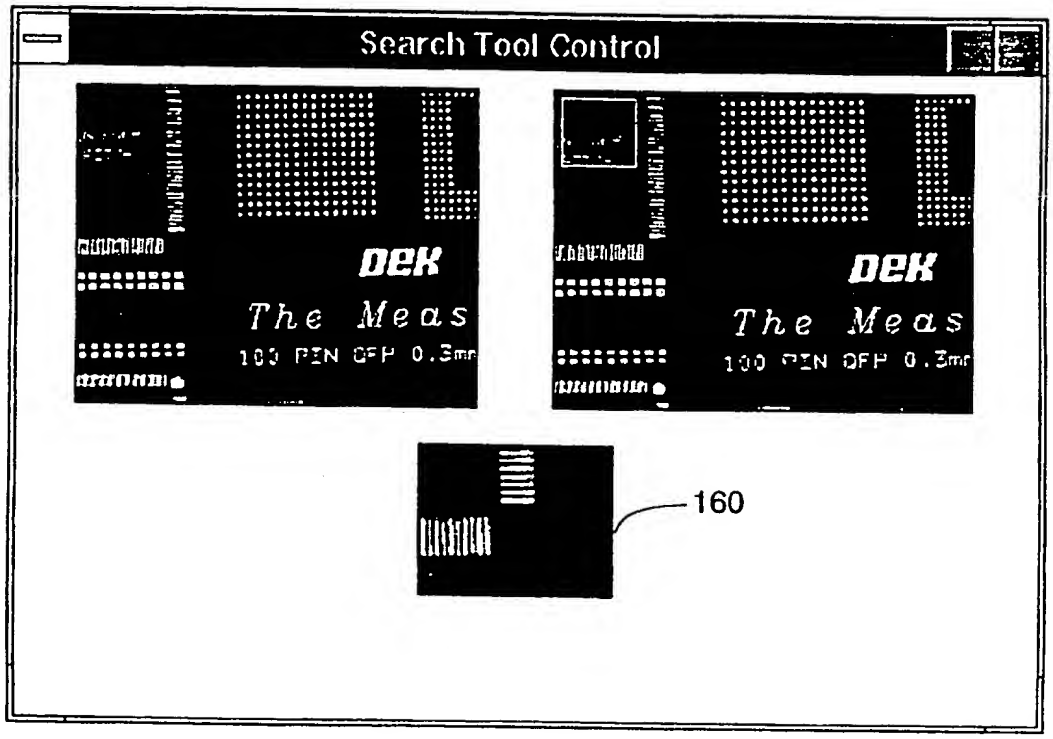
Search Tool Control
DEK
The Meas
100 PIN QFP 0.3mm
DEK
The Meas
100 PIN QFP 0.3mm
160

Fig. 16

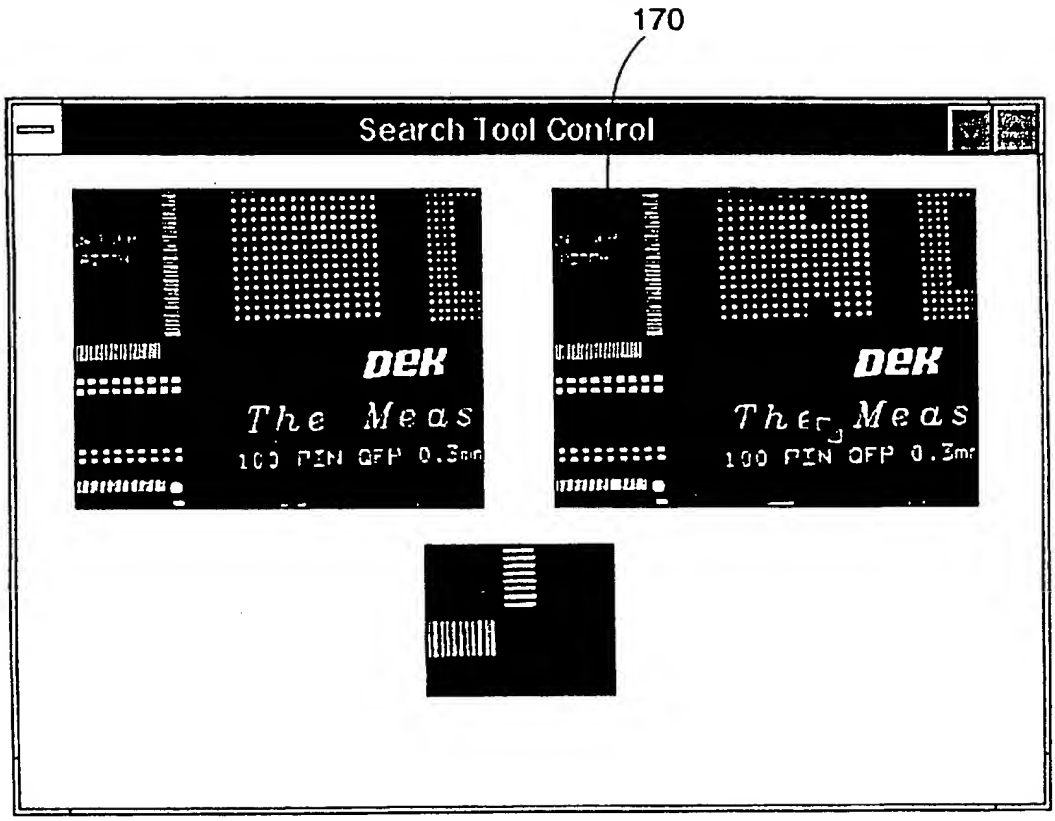

Fig. 17

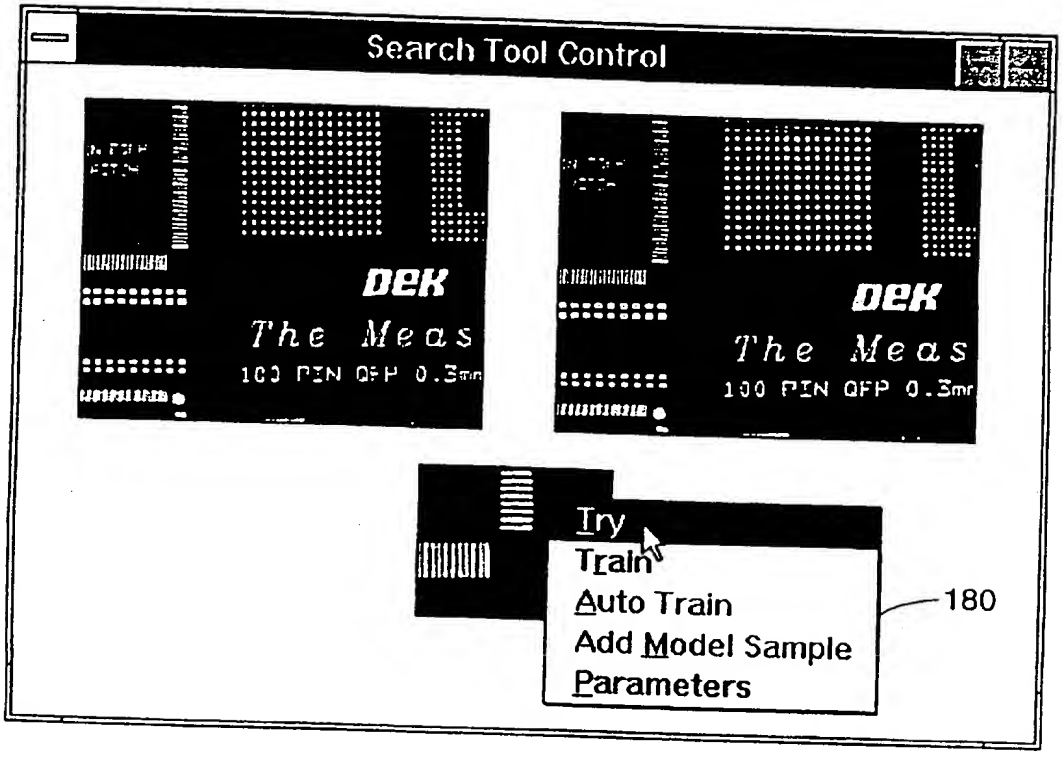
Search Tool Control
DEK
The Meas
100 PIN QFP 0.3mm
DEK
The Meas
100 PIN QFP 0.3mm
Try
Train
Auto Train
Add Model Sample
Parameters
180

Fig. 18

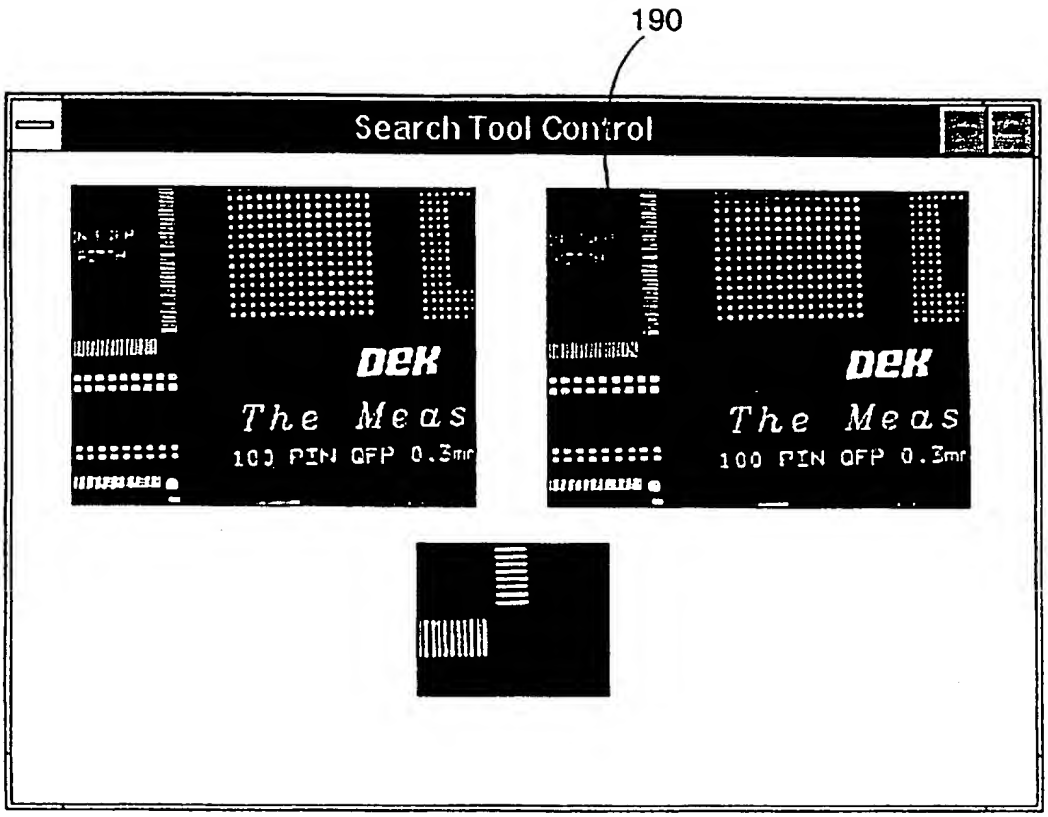
190
Search Tool Control
DEK
The Meas
100 PIN QFP 0.3mm
DEK
The Meas
100 PIN QFP 0.3mm

Fig. 19

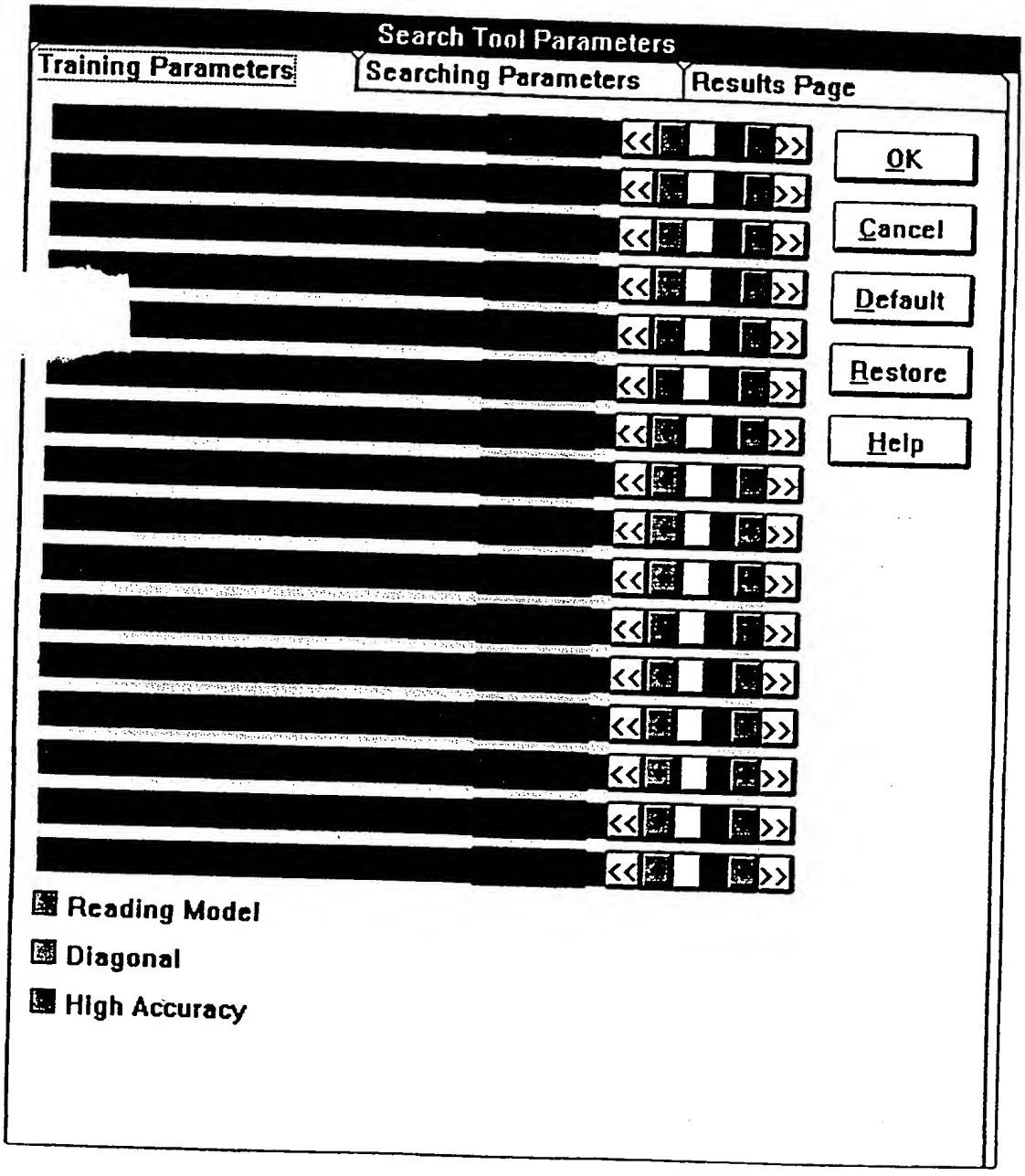
Search Tool Parameters
Training Parameters
Searching Parameters
Results Page
OK
Cancel
Default
Restore
Help
Reading Model
Diagonal
High Accuracy

Fig. 20

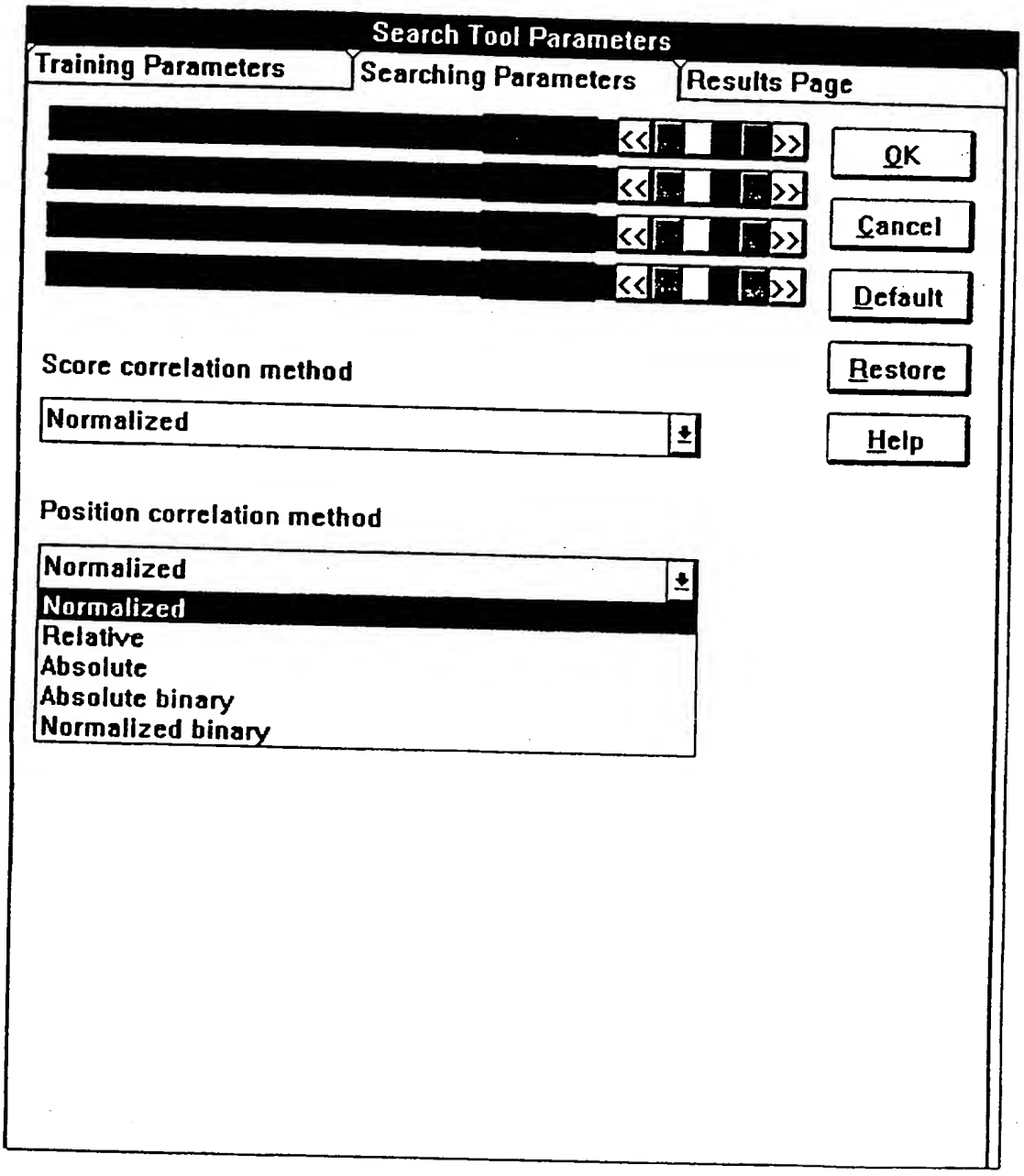
Search Tool Parameters
Training Parameters
Searching Parameters
Results Page
OK
Cancel
Default
Restore
Help
Score correlation method
Normalized
Position correlation method
Normalized
Normalized
Relative
Absolute
Absolute binary
Normalized binary

Fig. 21

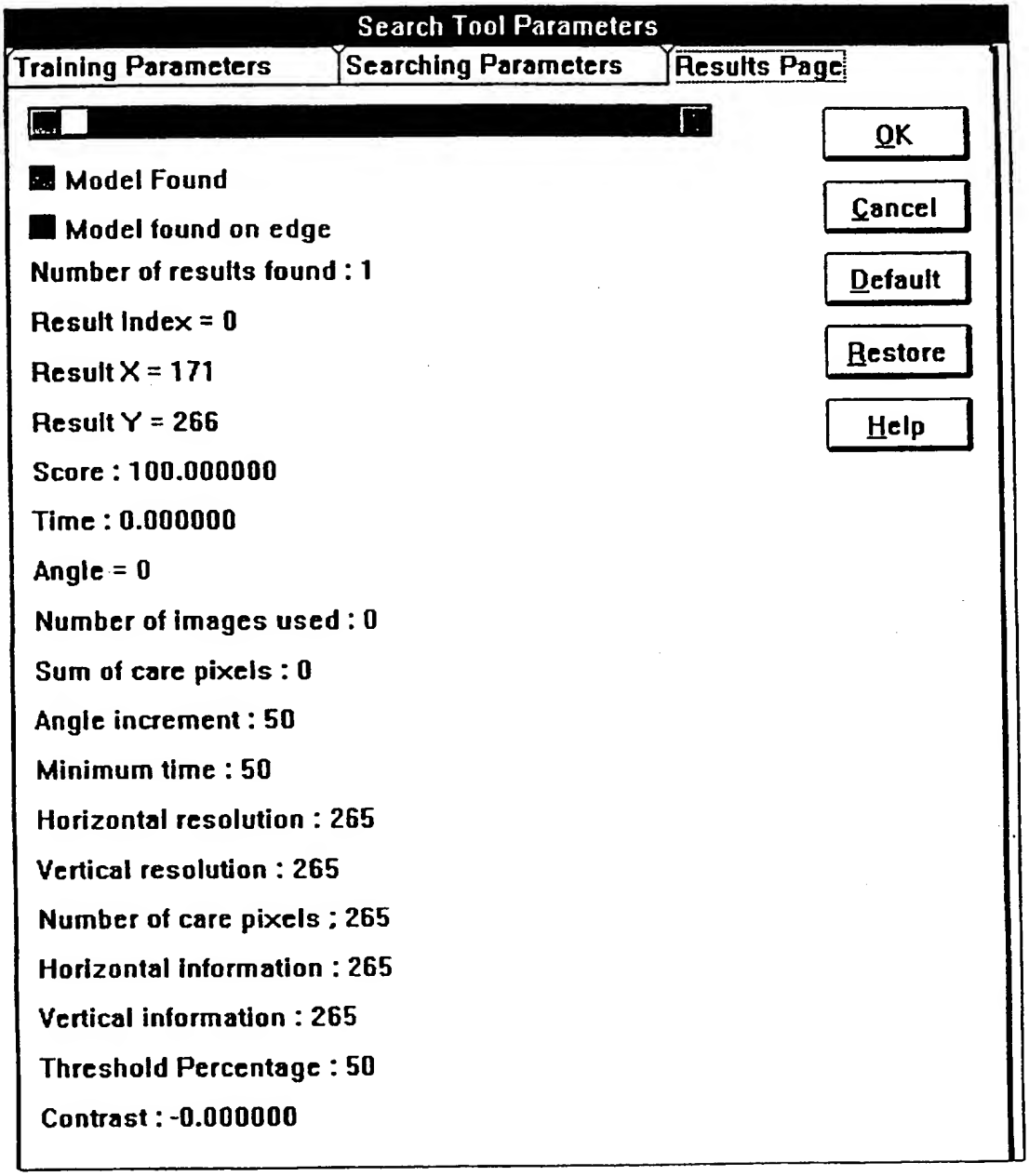
Search Tool Parameters
Training Parameters
Searching Parameters
Results Page
OK
Cancel
Default
Restore
Help
Model Found
Model found on edge
Number of results found : 1
Result Index = 0
Result X = 171
Result Y = 266
Score : 100.000000
Time : 0.000000
Angle = 0
Number of images used : 0
Sum of care pixels : 0
Angle increment : 50
Minimum time : 50
Horizontal resolution : 265
Vertical resolution : 265
Number of care pixels ; 265
Horizontal information : 265
Vertical information : 265
Threshold Percentage : 50
Contrast : -0.000000

Fig. 22

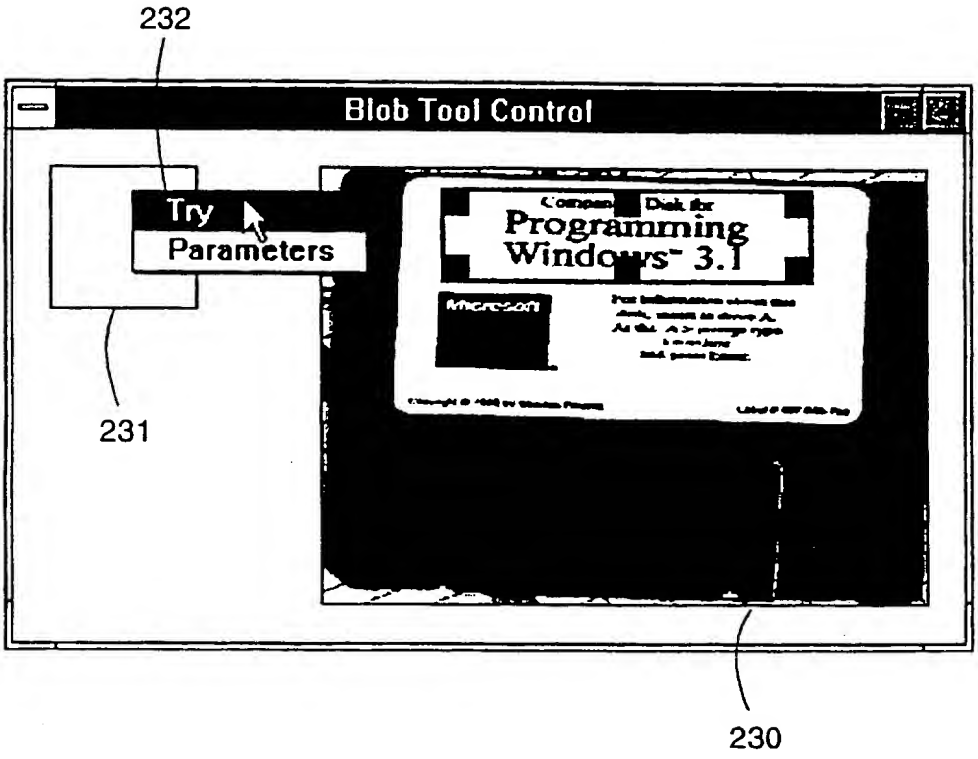

Fig. 23

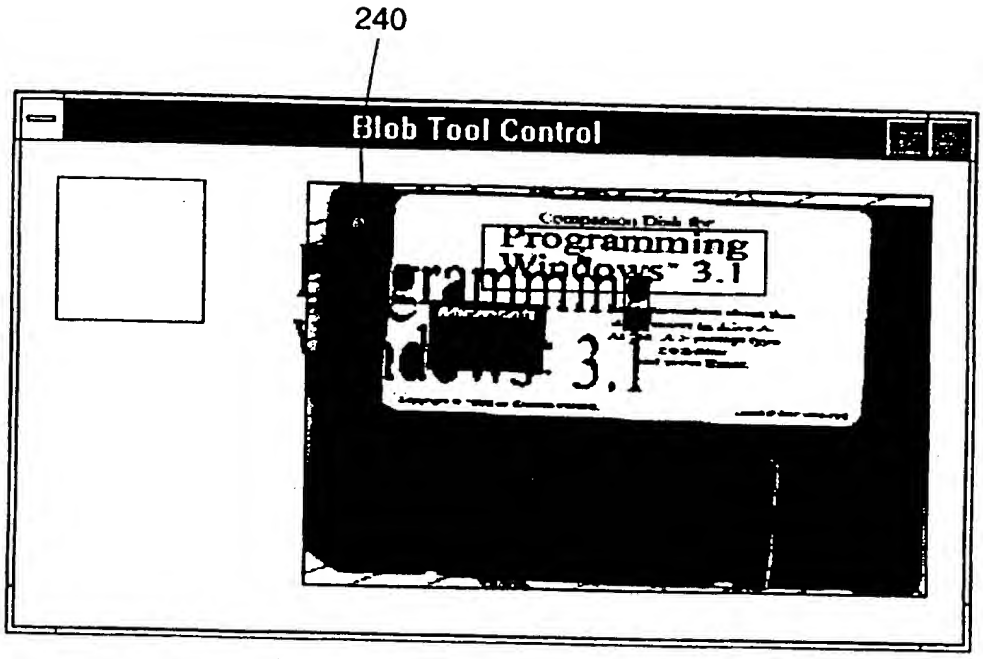

Fig. 24

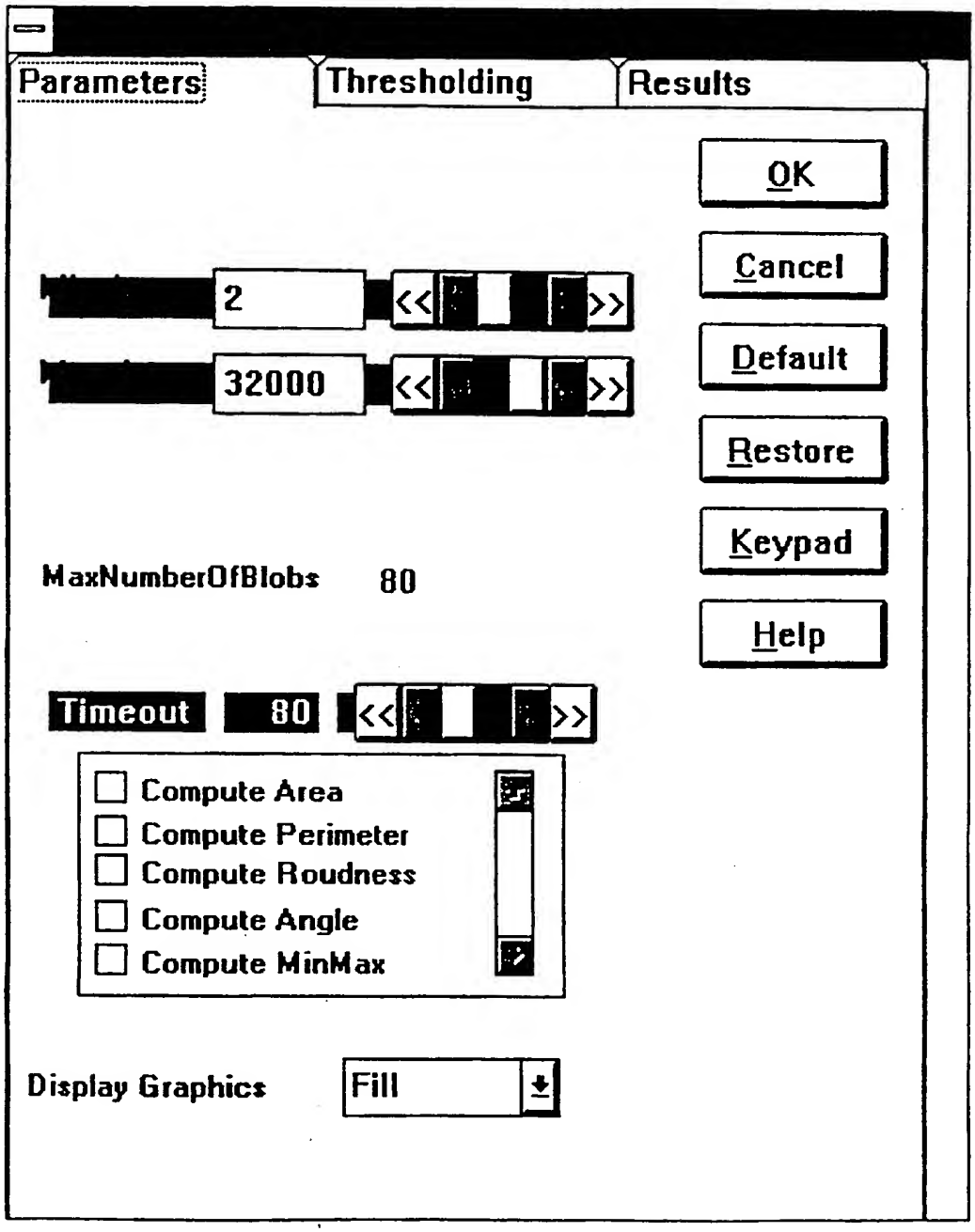
Parameters
Thresholding
Results
OK
Cancel
Default
Restore
Keypad
Help
2
32000
MaxNumberOfBlobs
80
Timeout
80
Compute Area
Compute Perimeter
Compute Roudness
Compute Angle
Compute MinMax
Display Graphics
Fill

Fig. 25

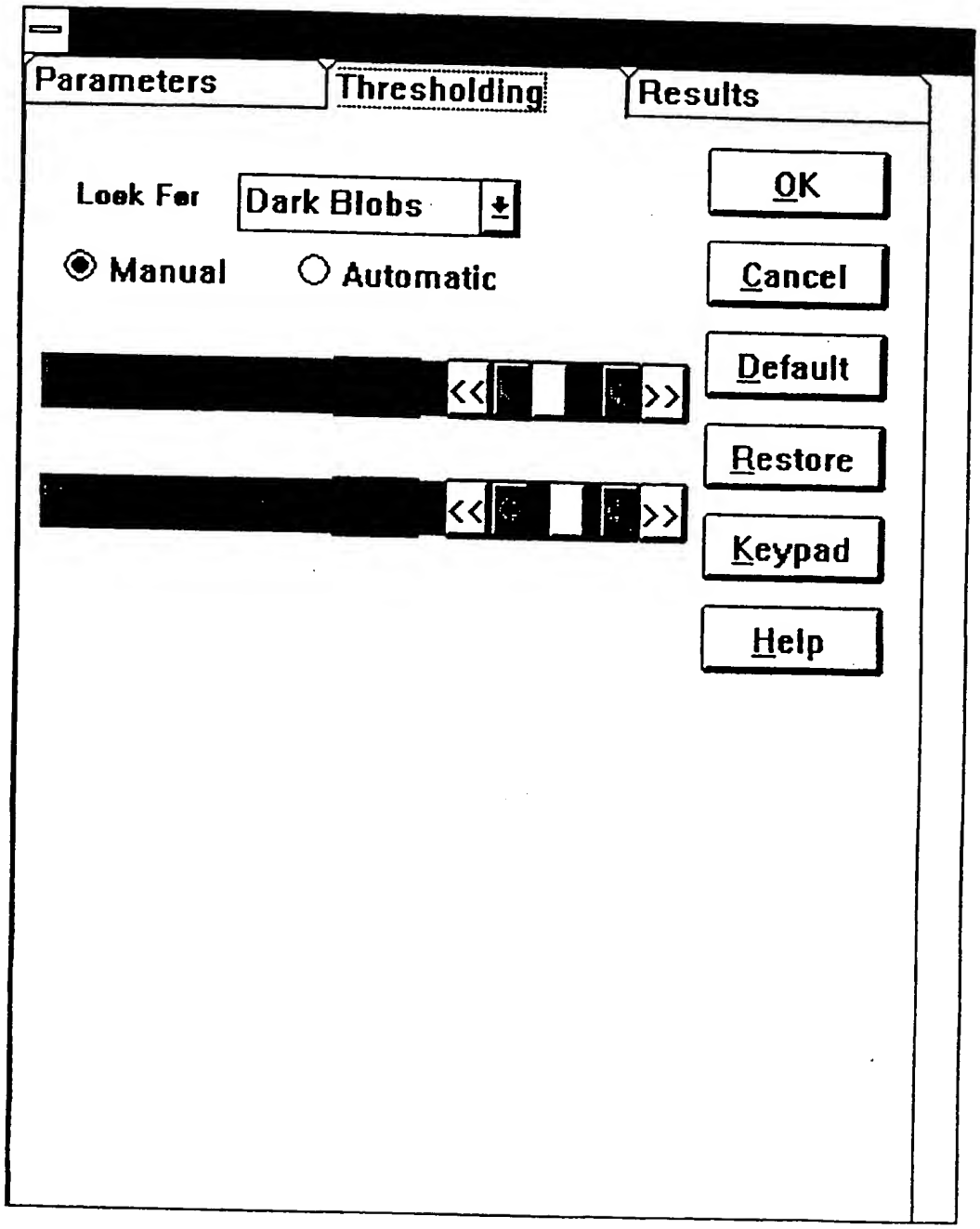
Parameters
Thresholding
Results
Look For
Dark Blobs
Manual
Automatic
OK
Cancel
Default
Restore
Keypad
Help

Fig. 26

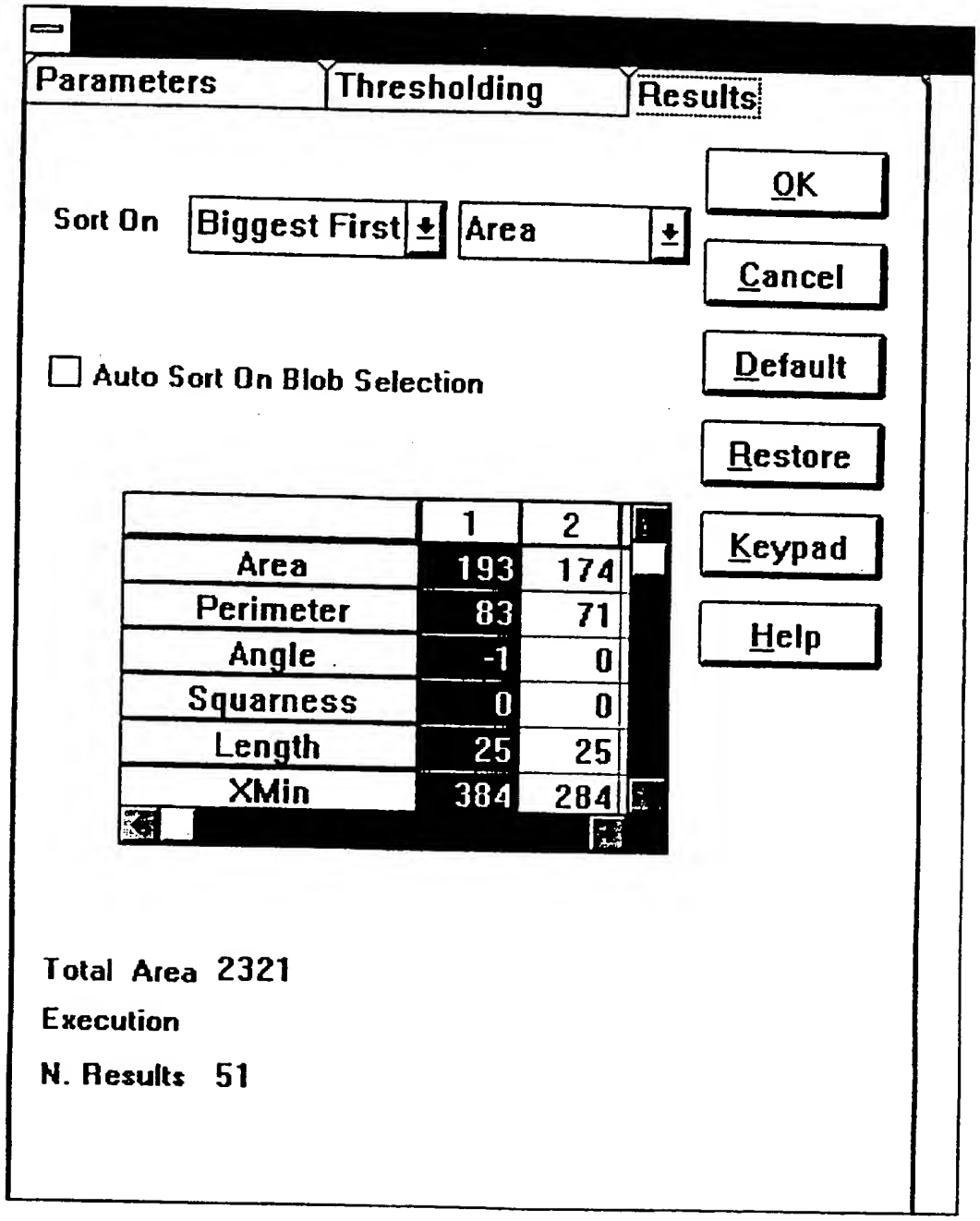
Parameters
Thresholding
Results
OK
Sort On
Biggest First
Area
Cancel
Auto Sort On Blob Selection
Default
Restore
Keypad
Help
1
2
Area 193 174
Perimeter 83 71
Angle -1 0
Squarness 0 0
Length 25 25
XMin 384 284
Total Area 2321
Execution
N. Results 51

Fig. 27

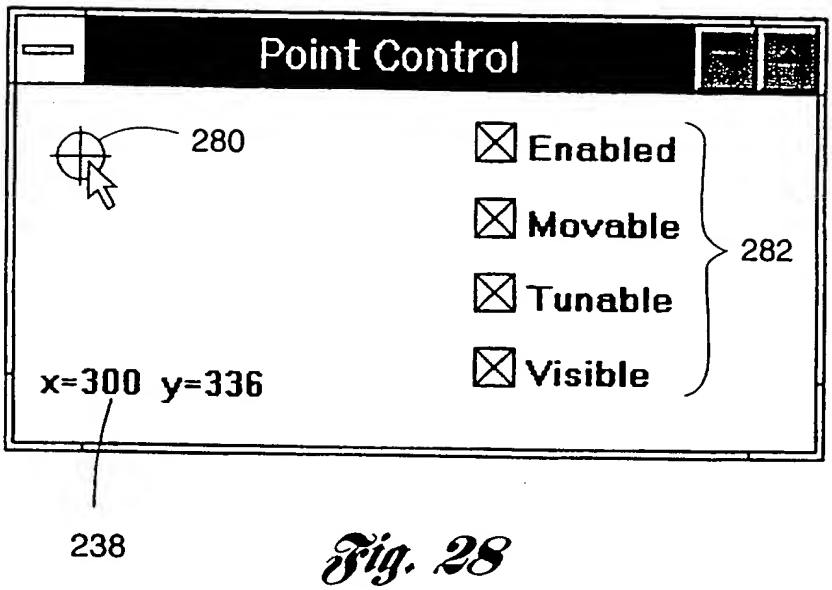
Point Control
280
Enabled
Movable
Tunable
Visible
282
x=300 y=336
238

Fig. 28

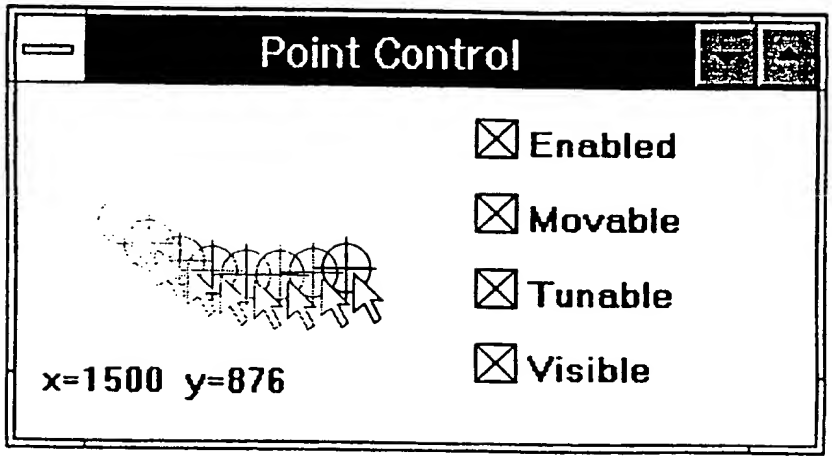
Point Control
Enabled
Movable
Tunable
Visible
x=1500 y=876

Fig. 29

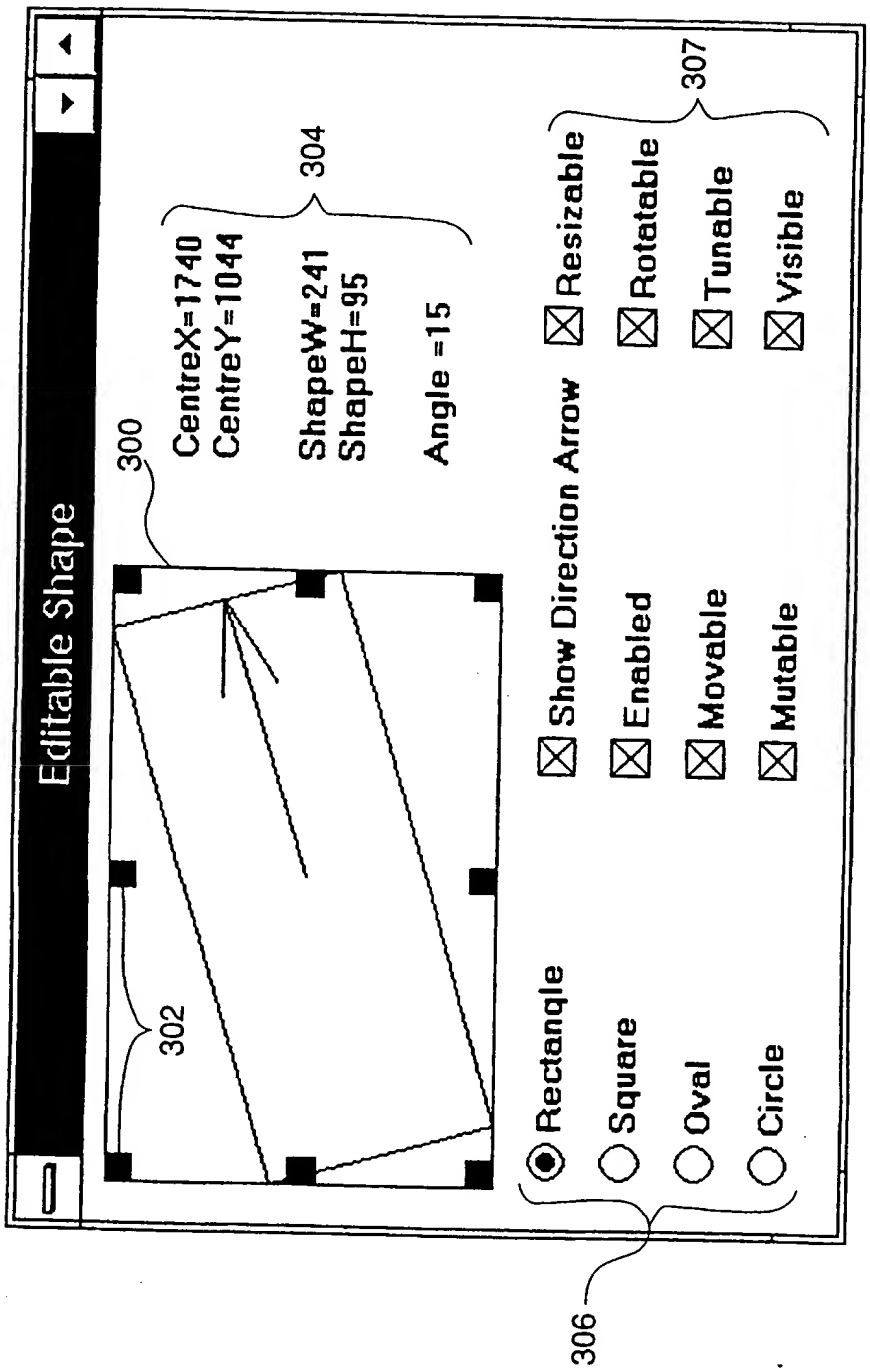
Editable Shape
300
302
CentreX=1740
CentreY=1044
ShapeW=241
ShapeH=95
Angle =15
304
Rectangle
Square
Oval
Circle
306
Show Direction Arrow
Enabled
Movable
Mutable
Resizable
Rotatable
Tunable
Visible
307

Fig. 30

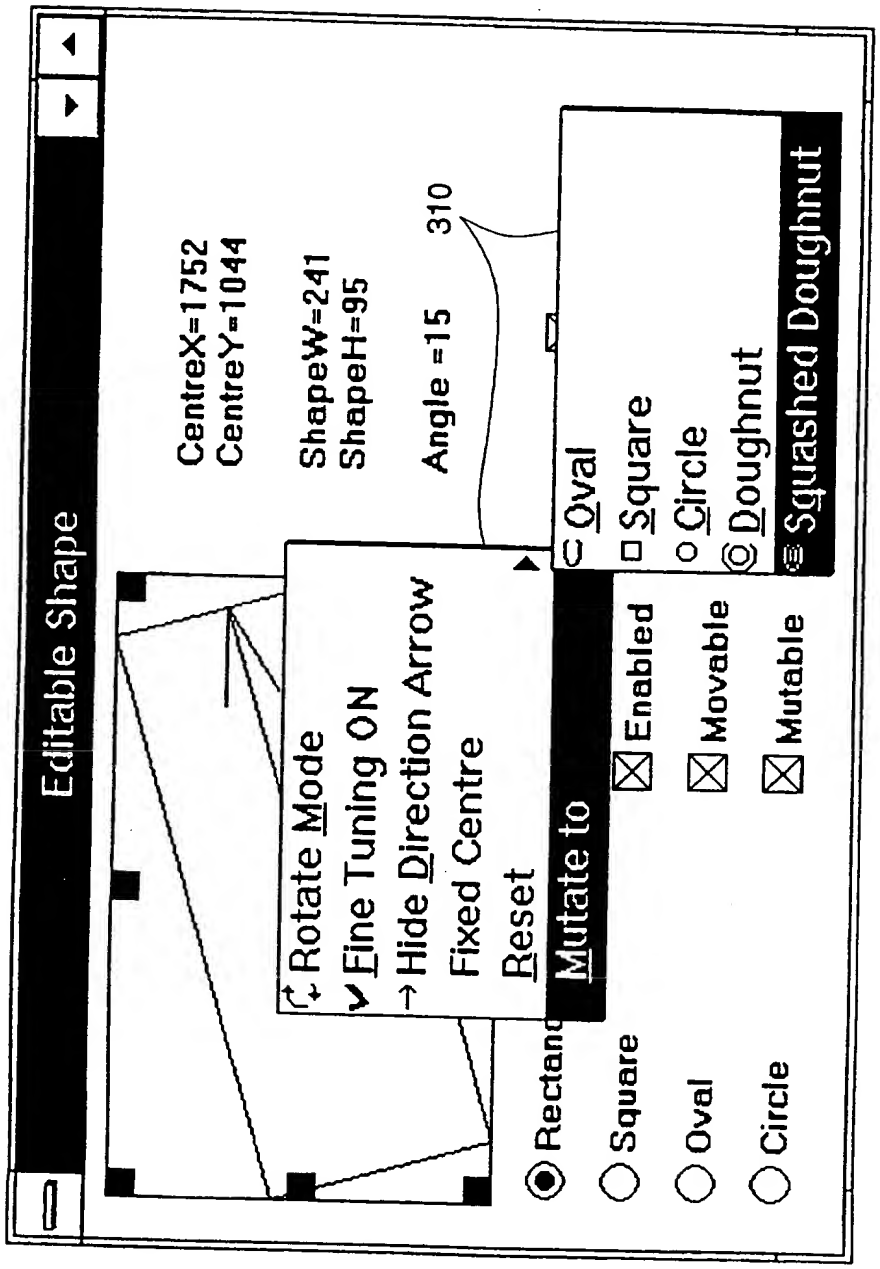
Editable Shape
CentreX=1752
CentreY=1044
ShapeW=241
ShapeH=95
Angle =15
310
Rotate Mode
Fine Tuning ON
Hide Direction Arrow
Fixed Centre
Reset
Mutate to
Oval
Square
Circle
Doughnut
Squashed Doughnut
Enabled
Movable
Mutable
Square
Oval
Circle

Fig. 31

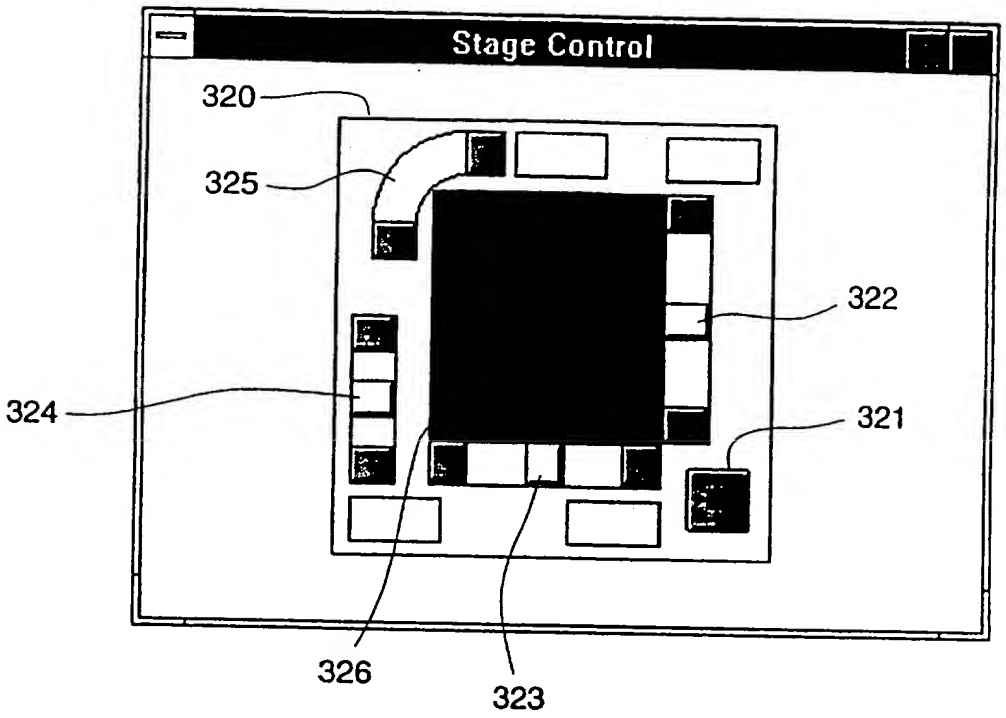
Stage Control
320
325
322
324
321
326
323

Fig. 32

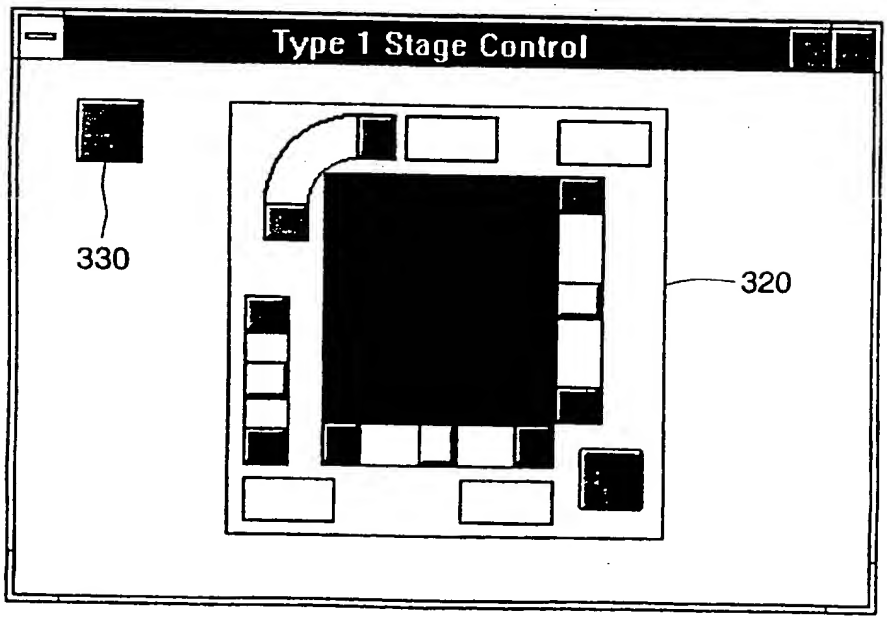
Type 1 Stage Control
330
320

Fig. 33

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/16999

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :G05B 19/42
US CL :364/188, 194

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 364/188,194

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

APS

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,434,629 A (PEARSON ET AL) 18 July 1995, col. 6, lines 23-60.	1-32
Y	US 5,416,392 A (LEE ET AL) 16 May 1995, col. 13, lines 18-68.	1-32
Y	US 5,170,352 A (MCTAMANEY ET AL) 08 December 1992, fig. 4.	1 and 17
Y	US 4,922,434 A (FULE) 01 May 1990, fig. 1.	1-32
Y	US 4,928,313 A (LEONARD ET AL) 22 May 1990, fig. 4.	1-32

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be part of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 JANUARY 1997	11 MAR 1997
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer Reba I. Elmore Telephone No. (703) 305-9706

Form PCT/ISA/210 (second sheet)(July 1992)★